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CHARACTERISTIC FOR A MODERATE ACCURACY INERTIAL NAVIGATION SYST--ETC(U)
AUG 79

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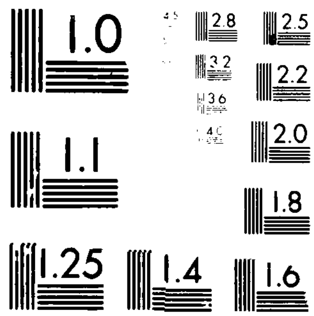

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

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TECHNICAL EXHIBIT - ENAC 77-1, Rev 2
Complete Reprint Supercedes ENAC 77-1;
ENAC 77-1, Rev 1; ENAC 77-1, Rev 1,
Amendments 1, 2 and 3

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LEVEL II

CHARACTERISTIC

FOR A MODERATE ACCURACY

INERTIAL NAVIGATION SYSTEM (INS)

24 August 1979

AERONAUTICAL SYSTEMS DIVISION

AIR FORCE SYSTEMS COMMAND

WRIGHT-PATTERSON AFB, OHIO

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Any questions or comments addressing the material contained in this document may be forwarded to:

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Commercial 513-255-5153

1.0 SCOPE. This specification establishes the requirements in terms of form, fit and function (including performance) for an inertial navigation system applicable to a broad spectrum of vehicles. It is the intent of this specification to define the INS requirements to a sufficient extent to allow multiple contractor designed and produced hardware to be used interchangeably at the LRU level in any given vehicle.

2.0 APPLICABLE DOCUMENTS

2.1 Government Documents. The following documents shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered as superseding requirements.

SPECIFICATIONS

Military

MIL-B-5087B, Amend 2 31 Aug 1970	Bonding, Electrical, and Lighting Protection for Aerospace Systems
MIL-E-5400R 31 Oct 75	Electronic Equipment, Airborne, General Specification for
MIL-H-5606C(1) 19 Nov 73	Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance
MIL-T-5624J 30 Oct 1973	Turbine Fuel, Aviation Grade JP-4 and JP-5
MIL-E-6051D(1) 5 Jul 1968	Electromagnetic Compatibility Requirements, Systems
MIL-M-7793D 31 Dec 1969	Meter, Time Totalizing
MIL-L-7808G(2) 10 Sep 1971	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-C-38999F(1) 1 Dec 1975	Connector, Electrical Circular, Miniature
MIL-C-83723C(1) 1 Oct 1975	Connector, Electric, Circular Environment Resisting, General Specification for
MIL-C-83733A 1 Oct 1975	Connector, Electrical, Miniature, Rectangular Type, Rack to Panel, Environmental Resisting, 200 Degrees C Total Continuous Operating

STANDARDS

Military

MIL-STD-108E 16 Aug 66	Definition of and Basic Requirement for Electrical and Electronic Equipment
MIL-STD-130D(3) 1 Aug 73	Identification Marking of U.S. Military Property
MIL-STD-454E 1 Mar 76	Standard General Requirements for Electronic Equipment
MIL-STD-461A, Not. 3 1 May 70	Electromagnetic Interference Characteristics, Requirements for Equipment, Subsystems and Systems
MIL-STD-462, Not. 2 1 May 70	Electromagnetic Interference Characteristics, Measurements of
MIL-STD-471A 1 Jan 75	Maintainability Demonstration
MIL-STD-704A 9 Aug 66	Electric Power, Aircraft Characteristics and Utilization of
MIL-STD-781B 15 Nov 67	Reliability Tests Exponential Distribution
MIL-STD-810C 10 Mar 75	Environmental Test Methods
MIL-STD-882 15 Jul 69	System Safety Program for Systems and Associated Subsystems and Equipment, Requirements for
MIL-STD-883A(1) 15 Nov 74	Test Methods and Procedures for Microelectronics
MIL-STD-1472A 15 May 70	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1553A 30 Apr 75	Aircraft Internal Time Division Command/Response Multiplex Data Bus
MS-17322-10 31 Dec 69	Meter, Time Totalizing, Miniature Digital 115V, 400 Hz

MS-25083-2 21 Feb 74	Jumper Assembly, Electric Bonding and Current Return
MS-25271D 19 Feb 70	Relay
MS-33660A 28 Oct 59	Tubing End, Hose Connection Standard Dimensions for (ASG)

OTHER PUBLICATIONS

AFM-39-1 29 Dec 69	Airman Classification Manual
AFSC DH 1-4	Design Handbook for Electromagnetic Compatibility
AFSC DH 1-6	Design Handbook for System Safety
FAR 121-89 Appendix G 29 Apr 72	Doppler Radar and Inertial Navigation Systems
OSHA Standard 1910-93 18 Oct 72	Code for Federal Regulations

3.0 REQUIREMENTS

3.1 Item Description. This INS shall be a self-contained, all-attitude navigation unit providing outputs of acceleration, velocity, position, heading, attitude (roll, pitch and azimuth) and a time word. The system shall require vehicle electrical power, turn-on and mode commands, initialization data and barometric altitude data for unaided inertial operation. In addition, the system shall be capable of interfacing with an external computer, via serial digital multiplex lines, which can request data and transmit update data based on their avionics sensors (e.g., doppler radar, position fixes, GPS, etc.). The INS shall be comprised of three (3) line replaceable units (LRU):

a. Inertial Navigation Unit (INU)
b. Control Display Unit (CDU) (Reference Only)
c. INU Mount

3.1.1 Item Diagram. Figure 1 is a pictorial description of the three (3) LRUs which comprise the INS with standard interconnecting wiring shown for reference only.

3.1.2 Interface Definition. The signal interface between the INU

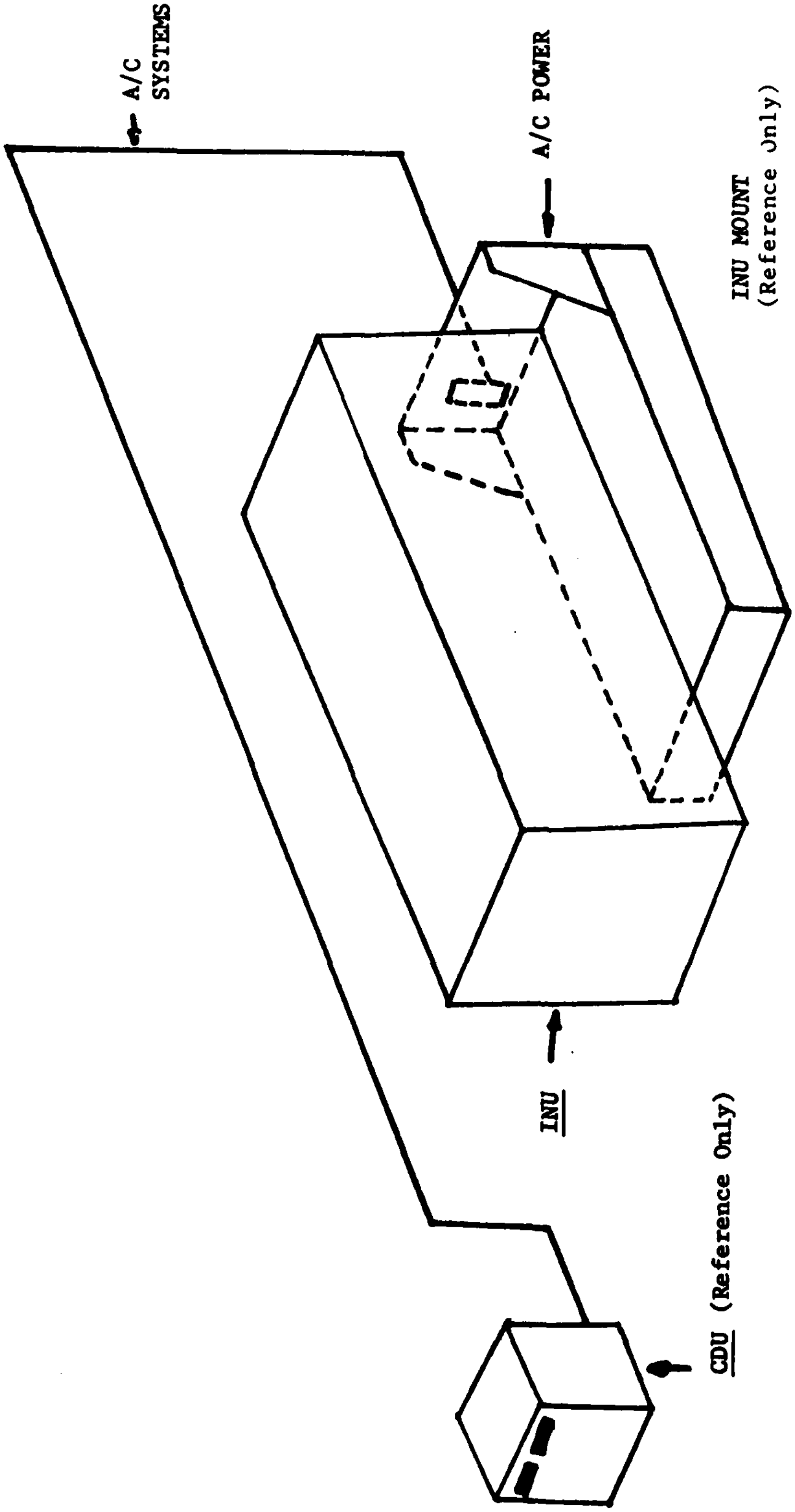

FIGURE 1 - INERTIAL NAVIGATION SYSTEM

and vehicle avionics shall conform to the input/output signals listed in Appendices I, II, III and VI. The parameters which the INS shall provide to and receive from other vehicle avionics shall be grouped into message sets as referenced in the appendices. Serial digital data transfer between the INS and other avionics subsystems shall be accomplished in accordance with Appendix VI.

3.1.2.1 Bus Control. In accordance with Appendix VI, paragraph 60.4.6.

3.1.2.1.1 Data Bus Redundancy. In accordance with Appendix VI, paragraph 60.4.5 and 60.4.6.3.2.

3.1.2.1.2 Bus Address. In accordance with Appendix VI, paragraph 60.4.2.3.5.1.2.

3.1.2.1.3 Status Word Bit Assignment. In accordance with Appendix VI, paragraph 60.4.2.3.5.3.

3.1.2.1.4 Mode Commands. In accordance with Appendix VI, paragraph 60.4.2.3.5.1.7.

3.1.2.1.5 Input/Output (I/O). The I/O shall contain registers and the associated logic necessary to receive and transmit serial binary coded decimal (BCD) and binary (BNR) data. Analog I/O shall be comprised of solid-state devices and external excitation shall be used for all digital-to-analog signals. 28 VDC discrete signal power shall be furnished by the vehicle DC bus through pins 5 and 6 of connector J132.

3.2 Characteristics.

3.2.1 Performance. These performance requirements apply for all flight and ground environments called out in paragraph 3.2.5 and its subparagraphs. The INS shall be capable of determining position, velocity, heading, and attitude to the accuracies specified herein in an autonomous mode from take-off to landing after a ground alignment in any of the following modes:

a. Gyrocompassing (GC)
b. Stored Heading
c. Best Available True Heading (BATH)

3.2.1.1 Position Accuracy. The INS shall provide present position determination with a radial error of 0.8 nautical miles/hr (1.48 kilometer/hr) CEP or less for flight times up to one hour after a complete gyrocompass alignment. For flight times greater than one

hour (with a gyrocompass alignment), the INS shall meet the performance requirements set forth for the civil environment (FAR 121-89, Appendix G) which states that "...the Inertial Navigation System must meet the following accuracy requirements, as appropriate:

a. For flights up to 10 hours duration, no greater than 2.0 nautical miles per hour (3.7 kilometers/hr) of circular error on 95 percent of system flights completed is permitted.

b. For flights over 10 hours duration, a tolerance of ±20 nautical miles (37 kilometers) cross track and ±25 nautical miles (46 kilometers) along-track on 95 percent of system flights completed is permitted..."

Navigation performance shall be 3.0 nautical miles/hr (5.6 Km/hr) CEP or less after a stored heading alignment per Table 1.

3.2.1.2 Velocity Accuracy. The X and Y horizontal velocity errors shall not exceed 2.5 fps (0.76 meter/sec) RMS per axis up to two hours in the navigate mode after a gyrocompass alignment, and not to exceed 5 fps (1.52 meter/sec) RMS per axis in the navigate mode after a stored heading alignment. The vertical velocity error shall not exceed 2.0 fps (0.61 meter/sec) RMS after a gyrocompass alignment and 3.0 fps (0.91 meter/sec) RMS after a stored heading alignment. These accuracies will be maintained throughout the environments specified in paragraph 3.2.5 and its subparagraphs.

3.2.1.3 Reaction Times. Gyrocompass alignment shall be completed in 9 minutes or less at or above 0°F (-17.7°C) and 12 minutes or less at -40°F (-40°C). Stored heading or best available true heading shall be completed in 2.5 minutes or less at 0°F (-17.7°C) and 4 minutes or less at -40°F (-40°C). Alignment times for other conditions of temperature are provided in Table 1. All times given include warm-up time. A steady "NAV RDY" indication shall be displayed on the CDU when the system will support degraded navigation.

3.2.1.4 Attitude Accuracy. Attitude information shall be available at the system outputs within the accuracies and within the maximum time limits specified in Table 1 as a function of temperature and alignment scheme. A signal shall be provided to the CDU to select a steady "NAV RDY" light when attitude data is available.

3.2.1.5 Latitude Range/Vehicle Motion During Alignment. The INS shall meet the requirements of this specification for alignments between 78°N and 78°S latitude, with normal wind buffeting and normal ground maintenance activities.

3.2.1.6 Performance Certification. Verification as specified in

TABLE I

ALIGNMENT TIME AND ATTITUDE ACCURACY

1 HOUR FLIGHT

ALIGNMENT MODE	TIME TO ALIGN FROM		
GYROCOMPASS (GC)	-40°F (-40°C)	0°F (-17.7°C)	70°F (21.1°C)
1) Full Accuracy (0.8 nm/hr CEP)	12.0 min	9.0 min	8.0 min
2) Degraded Accuracy	6.0 min ($\leq$8.0nm/hr CEP)	6.0 min ($\leq$5.0nm/hr CEP)	6.0 min ($\leq$5.0nm/hr CEP)
STORED HEADING (SH)			
1) Full Accuracy (3.0 nm/hr CEP)	4.0 min	2.5 min	1.5 min
2) Degraded Accuracy	2.0 min ($\leq$8.0nm/hr CEP)	2.0 min ($\leq$5.0nm/hr CEP)	NOT APPLICABLE
BATH ALIGNMENT	2.0 min	2.0 min	1.5 min

ATTITUDE ACCURACY

1. Roll and Pitch Attitude (all align modes) - 0.1° RMS, Static Accuracy
2. True Heading (GC and SH align modes) - 0.1° RMS, Static Accuracy
3. Heading Drift (attitude mode) - 15°/hr Maximum

paragraph 4.2.2 is required as the basis for certifying compliance with the INS performance requirements.

3.2.1.7 INS Functions. The INS shall provide the following functions:

a. Present Position Insertion. Provide for manually inserting local geodetic latitude and longitude and alpha numeric UTM coordinates via the CDU.

b. Align Status. Provide an align progress indication during alignment that signifies expected performance if the navigate mode is selected at any point in time, and an indication when the alignment is sufficiently accurate to provide the specified performance.

c. Calibration. Calibration shall be required no more frequently than 60 days. A vehicle self-calibration for Gimballed systems shall be accomplished without the use of any special test equipment and shall not exceed 90 minutes.

d. Automatic Magnetic Variation Computation. The INS shall automatically compute magnetic variation in all regions of the earth between 72 degrees north and 60 degrees south latitude. Magnetic variation from this computation shall be added in the INU to true heading in the computation of all magnetic heading outputs; however, if magnetic variation has been hand entered, it shall be used in lieu of computed magnetic variation. The ability to select/deselect manually entered variation shall be provided. The accuracy of the magnetic variation computation shall be ± 0.2 degrees assuming that reference data (similar to C-141 table, "GEO MAG" with coefficients and partials, or equivalent) supplied by the government is errorless.

e. Self-Test. Provide for inflight and on-the-ground self-test to monitor INU and CDU operation and provide an appropriate indication when the INU is not operating properly in addition to transmitting a degraded mode signal(s) to other equipment. Fault codes for the INU malfunctions shall be stored in the non-volatile memory.

f. Attitude. Determine and maintain a continuous knowledge of the vehicle attitude relative to local geodetic vertical, transmit roll and pitch to other equipment, and serve as a back up attitude reference in the "ATT" mode.

g. True Heading. Determine and maintain a continuous knowledge of the vehicle longitudinal axis azimuth relative

to true north, and transmit true heading to other equipment or accept true heading as manually inserted via the CDU during a BATH alignment.

h. Acceleration. Determine and maintain a continuous knowledge of the vehicle acceleration and transmit the three orthogonal accelerations in the INU reference frame (X, Y, and coriolis/local g corrected Z) to other equipment.

i. Velocity. Determine and maintain a continuous knowledge of the vehicle velocities relative to the ground and transmit the three orthogonal velocities in the INU reference frame (X, Y, and coriolis/local g corrected Z) to other equipment.

j. Present Position. Continuously compute and display, on selection via the CDU, vehicle present position in geodetic latitude and longitude coordinates or alpha-numeric UTM coordinates, and transmit these coordinates to other equipments.

k. Position Update. Correct present position while airborne by (1) overflying a known position which has been inserted via the data bus or (2) accepting present position signals via a correction vector. When either the "AUXILIARY" or "OVERFLY" update mode described in paragraph 3.2.1.8f herein is selected, the difference between INU computed present position and the actual known position (however inserted) shall be computed as N/S and E/W errors in nautical miles and tenths and transmitted via the data bus to the CDU for display (note exception in paragraph 3.2.1.8f.3 for the unique CDU interface). When the "AIR ALIGN" update mode described in paragraph 3.2.1.8f herein is selected, the present "pure inertial" position is replaced with the input sensor present signals contained in the correction vector.

l. Steering. Compute and make available as outputs course, course deviation, range to destination, time destination, ground track and steering error for steering to any of 10 destinations and six Markpoint locations. When the INU is interfaced with the Unique CDU, three Markpoints may be transmitted to the INU on the MUX bus under external computer control, or three Markpoints may be established internal to the INU in response to a CDU Mark command. When the INU is interfaced with a Generalized CDU, three Markpoints may be transmitted to the INU on the MUX bus under external computer control, or six Markpoints may be transmitted to the INU from the CDU or established internal to the INU in response to a CDU mark command or a Designate Discrete Mark Command when an overfly fix (Function Select Code 00101) is not being commanded.

m. Back Up Bus Control. Serve as a back up controller for a maximum of two serial data buses.

n. Back Up Attitude. Serve as a back up attitude reference.

o. Align Time. The align status and the time that the set is in the align mode shall be determined and stored in the nonvolatile memory.

p. Mode Status. A mode status indication in the form of a mode word shall be provided to the interfacing weapon system via the serial digital lines indicating an INU controlled mode status, including indication of when a position and velocity update is applied.

q. INS Performance Monitor. The INS shall provide a history of recent navigation performance and record of alignment events prior to the latest flight (e.g., vehicle movement during alignment). The navigation performance shall provide an indicator based upon radial error rate of prior flights. The last flight event indication shall provide a record of occurrences that affect system performance.

3.2.1.8 Selectable Modes. The INS shall be capable of operating in the following modes. These modes shall be selectable from the CDU via the serial data bus except turn-on (not off) and the "ATT" mode which are hard wire discrete inputs. During the INS alignment modes, the INS shall provide signals to the outside source which are adequate to determine the covariance matrix of the errors in the INS output signals.

a. Off Mode. All input power shall be removed from all INS circuits except for (1) input EMI filter loads, and (2) for simple circuits required to respond to the power-on command.

b. "GC" Alignment Mode. In this alignment mode, present position shall be entered via the CDU, then a gyrocompass alignment shall be performed in azimuth to determine the vehicle true heading. During alignment, the INU shall compute, and make available for display at the CDU, an alignment status indication which is proportional to navigation performance. The INU shall provide a signal for selection of a flashing "NAV RDY" light on the CDU when the set will provide performance as specified in paragraph 3.2.1. Also, a signal shall be provided to select a steady "NAV RDY" light on the CDU not later than the time specified in Table I so "NAV" can be entered (at the pilot's option) to give a rapid gyrocompass capability. The insertion of present position shall be inhibited after two minutes in the "GC" alignment mode.

c. "STOR HDG" Alignment Mode. In this fast alignment mode, the INS shall level to local vertical and align to the last stored heading. As a pre-requisite for a stored heading alignment, the vehicle is spotted and a complete gyrocompass alignment is performed before the INS is shut down. The vehicle is not moved prior to the next alignment. A signal shall be provided to the CDU to select a steady "NAV RDY" light when the "NAV" mode can be entered with degraded performance. A signal shall also be provided to the CDU to select a flashing "NAV RDY" light when the set will provide performance as specified in 3.2.1, but not later than the times specified in paragraph 3.2.1.3. During the "GC" and "STOR HDG" modes, the INS will define the quality of navigation performance to be expected should alignment be terminated for entry into the "NAV" mode.

d. "BATH" Alignment Mode. For the "BATH" alignment, the true heading is entered via the CDU or computed by application and entered via the MUX bus by any other source. A signal shall be provided to the CDU to select a flashing "NAV RDY" light when the INS will provide the performance as specified in paragraph 3.2.1. True heading from the CDU or an external source must be entered within one (1) minute after selecting the BATH mode. If true heading data is not entered within one minute, the INS shall use the true heading stored at the previous shut down as reference.

e. "NAV" Mode. This is the primary flight mode of operation and is entered after a satisfactory alignment upon receipt of a bit in a function switch word. If satisfactory alignment conditions are not met, the INS shall provide an appropriate output status indication. If the Nav mode is selected from the CDU prior to the INU's ability to support the NAV mode with MAG HDG GOOD, the INU will switch to the ATT mode and continue to indicate MAG HDG BAD, without storing a fault in the fault table.

While in the "NAV" mode, the vertical channel of the INS shall be mechanized to minimize degradation of altitude accuracy for intervals up to five minutes in duration and for transient flight conditions which cause the accuracy of barometric altitude to be degraded. The availability of barometric altitude shall be noted by an INU input bit ("Pressure Altitude Valid").

f. "UPDATE" Modes. In the update modes, the INS shall be capable of accepting corrections for selected system quantities from external sources via the data bus. This update capability will be available for the following quantities: Velocity (X and Y axes); Position; Gyro Tilt (X and Y axes); Gyro Drifts (X, Y, Z axes). If commanded from an outside source (via the data bus), the INS shall be able to apply these corrections and provide an acknowledge signal to an outside source (via the data bus). The acknowledge bit shall be set in the first computation cycle following reception of the update command. The following three update modes shall be available:

1. "AIR ALIGN". The Standard INS, in conjunction with sensor equipment, and a correction vector generated by an external computer, shall be capable of performing an inflight alignment. This same mode shall provide the capability for performing "aided" navigation (i.e., Automatic update).

2. "AUXILIARY". The INU shall be capable of accepting suitable position update data from outside sources such as radar, TACAN, and GPS via the data bus. Operator intervention via the CDU shall be required to either accept or reject the update (i.e., Semi-Automatic update). Position fix deltas computed between the input sensor present position location and the present "inertial display" position shall be transmitted via the data bus to the CDU for display. An operator accept decision shall cause these deltas to be applied to the present "inertial display" position. Present "pure inertial" position shall be transmitted to the CDU, as INU Miscellaneous Data, upon receipt of an appropriate "MISC PARAMETER READ" request from the CDU.

3. "OVERFLY". The INU shall be capable of being updated manually by overflying a known position. When interfaced with a "Unique CDU" the present "pure inertial" position shall be updated to match the selected steerpoint upon initial receipt of the designate discrete.

When interfaced with a "Generalized CDU", the following mechanization shall be used: Subsequent to selection of the overfly function, and upon receipt of either a digital update command from the CDU or a 28 VDC designate update discrete, position fix deltas shall be computed between the present "inertial display" position and a known position stored in the selected destination waypoint/markpoint location in the INU memory. These update position fix deltas shall be transmitted via the data bus to the CDU for display and operator accept/reject decision. Selection of alternate waypoints/markpoints (destinations), or insertion of new position information in the selected destination prior to receipt of the accept/reject command, shall cause new deltas to be computed relative to the re-defined known position and the new deltas shall be transmitted to the CDU for display and operator accept/reject decision. Upon receipt of an accept command from the CDU, the deltas relative to the latest selected destination shall be applied to the present "inertial display" position. When the INU is interfaced with a Generalized CDU, present "pure inertial" position shall not be updated using this update mode. Present "pure inertial" position shall be transmitted to the CDU, as INU Miscellaneous Data, upon receipt of an appropriate "MISC PARAMETER READ" request from the CDU.

g. "CAL" Mode. A calibration mode shall provide for automatic calibration of the azimuth component of gyro bias drift, in addition to the gyro bias drift terms calibrated during the alignment mode. The "CAL" mode shall require no more than 90 minutes to complete, and shall include provisions for updating the affected calibration constants stored in the INU. Calibration shall be no more frequently than 60 days.

The "CAL" mode shall be initiated by a bit in a serial word and shall require no external inputs other than vehicle present position for operation. It shall operate in the ground alignment environment, without the need for any Support Equipment (SE), and shall provide a status indication for output. No manual insertion of calibration data shall be required by organization level personnel either after calibration or at any other time for proper operation of the system. Excess time over ground alignment may be used to provide incremental calibration of the platform.

h. "ATT" Mode. The attitude mode is a back up mode mechanized as a first order leveling mode entirely within the INU and its associated electronics. It shall be capable of being initiated either by the INU Computer or by external control via an INS input discrete. The attitude mode shall be able to be initiated while the INS is moving or stationary and thereafter shall provide a stable reference frame for generation of roll, pitch and inertial heading angles.

i. "TEST" Mode. The "TEST" mode shall incorporate functional performance tests, fault detection, and fault localization checks. It shall be initiated by a bit in a serial word in conjunction with appropriate function and/or data select codes, and shall proceed automatically with no other requirements for external equipment or operator action. The combined capabilities of the "TEST" mode, the system Built-In-Test (BIT) and other operator observable conditions (e.g., results of in place navigation runs) shall have a 95% confidence level in fault detection on the vehicle, with the false alarm rate not to exceed 2%. The TEST mode shall be exercised with the INU stationary in the ground environment. It shall not require removal of the INU from its mount in the vehicle. While it is operating, the "TEST" mode shall provide system status indications for output.

j. "GRID" Mode. A grid navigation mode shall be implemented to compute grid heading from inertially derived true heading and a manually inserted convergence factor. The grid mode shall be manually selected. If a convergence factor is not entered by the operator, grid heading shall be computed using either a convergence factor of 1.0 or the INS computed convergence factor. Entry into the grid mode shall be enunciated. INS MAG heading outputs (digital and analog) shall be replaced by grid heading in this mode and it shall be possible to readout both true and grid heading on

the CDU during grid operation. Reversion to the normal navigation mode shall be possible at any time without system degradation.

3.2.1.9 Data Output. The INS shall output the signals specified in Appendix II during the "NAV" and "GRID" modes when applicable. During the "CAL" and "ALIGN" modes, the gyro and accelerometer parameters which are updated shall be available in a serial digital data stream.

3.2.1.10 Validity Output Discretes. The INS shall provide output discretes that define the validity of the analog output signals of roll, pitch and magnetic heading.

3.2.1.10.1 Attitude Good. The discrete that defines the validity of the roll and pitch analog output signals shall be set true (28 VDC) in the align, navigate, and attitude modes whenever the INS has an established vertical. The discrete shall be set false (open circuit) for any malfunction that would prevent the INS from maintaining a vertical reference or cause invalid analog output roll and pitch signals. The discrete shall be fail-safe to the false state.

3.2.2 Physical Characteristics.

3.2.2.1 Size. The INS shall comply with the form factor dimensions and tolerances as set forth in Appendix IV of this specification.

3.2.2.2 Electrical Interface. Figure 2 establishes the electrical interface for the Standard INU. It defines the signals by pin assignment.

3.2.2.3 Electrical Power. The INS shall operate with electric power having the characteristics specified by MIL-STD-704A for Category B equipment. INS performance and utilization of power shall be in accordance with MIL-STD-704A and the following:

a. The INS shall provide performance as specified herein when supplied electric power having the characteristics specified by MIL-STD-704A for the normal, abnormal and emergency modes of electric system operation. The applicable units for steady state and transient voltage and frequency are as follows:

AC POWER

115/200 volts, 3 phase, 400 Hz (nominal)
Steady state voltage - 104 to 122 volts (includes normal and emergency limits)
Steady state frequency - 360 to 440 Hz (includes normal, abnormal, and emergency limits)
Transient voltage-limits 1&4, Figure 3, MIL-STD-704A (includes normal and abnormal limits)
Transient frequency-limits 1&4, Figure 5, MIL-STD-704A (includes normal and abnormal limits)

DC POWER

28 volts (nominal)
Steady state voltage -16 to 30 volts (includes normal, abnormal, and emergency limits)
Transient voltage - limits 1&4, Figure 9, MIL-STD-704A (includes normal and abnormal limits)

b. The INS shall not be damaged when subjected to the steady state AC abnormal limits of MIL-STD-704A.

c. The INS shall not be damaged by the loss of one or more phases of AC power or by the total loss of power at any input terminal.

d. Vehicle Battery Power Source. The INU installation shall be capable of operating from the vehicle battery bus during power interrupts. Bus management and bus fault detection are the responsibility of the Bus Management System.

1. INS Requirement. The INS shall perform as specified herein when interfacing with a vehicle battery bus which has the following DC power supply characteristics.

a. Power. The vehicle battery bus voltage is a nominal 28 volts with a minimum and maximum value of 16 VDC and 30 VDC, respectively. The voltage remains within specification throughout a load range varying from 0 to 240 watts.

b. AC Ripple. The maximum allowable AC ripple voltage vs frequency is shown in MIL-STD-704A, Figure 7.

c. Line Transients. The line transients at the INS Vehicle Battery input terminals are in accordance with MIL-STD-704A, Figure 9, Curves 5 and 6.

2. INS Grounding. The Vehicle Battery source return (negative) shall be connected to the INS signal ground within the INS. Electrical isolation ($>10\ M\Omega$) shall be provided between the vehicle battery bus and the INS 28 VDC input terminals.

3. DC Voltage Drop Out. When the INS has transferred to the vehicle battery bus because of a prime failure, the INS shall monitor the bus voltage. If the bus voltage drops below the specified value, the INS shall initiate an orderly shutdown.

e. The INU power consumption shall not exceed that described in Table II.

f. The DC power consumption shall not exceed that described in Table IIa.

g. Degraded Performance. When operating steady state from the vehicle battery power source, the INS shall provide, in the navigate mode, position and velocity performance continuously with degraded accuracy not specified herein. If any power interrupt continues for more than 10 seconds during the align modes, the INS may initiate an orderly shutdown.

3.2.3 Reliability. Reliability will not be specified within the document, but will be covered by other documentation within the contract.

3.2.4 Maintainability.

3.2.4.1 Design. The maintainability of the INS shall be a prime consideration during equipment and installation design. The system shall be packaged in modular form for easy removal and replacement.

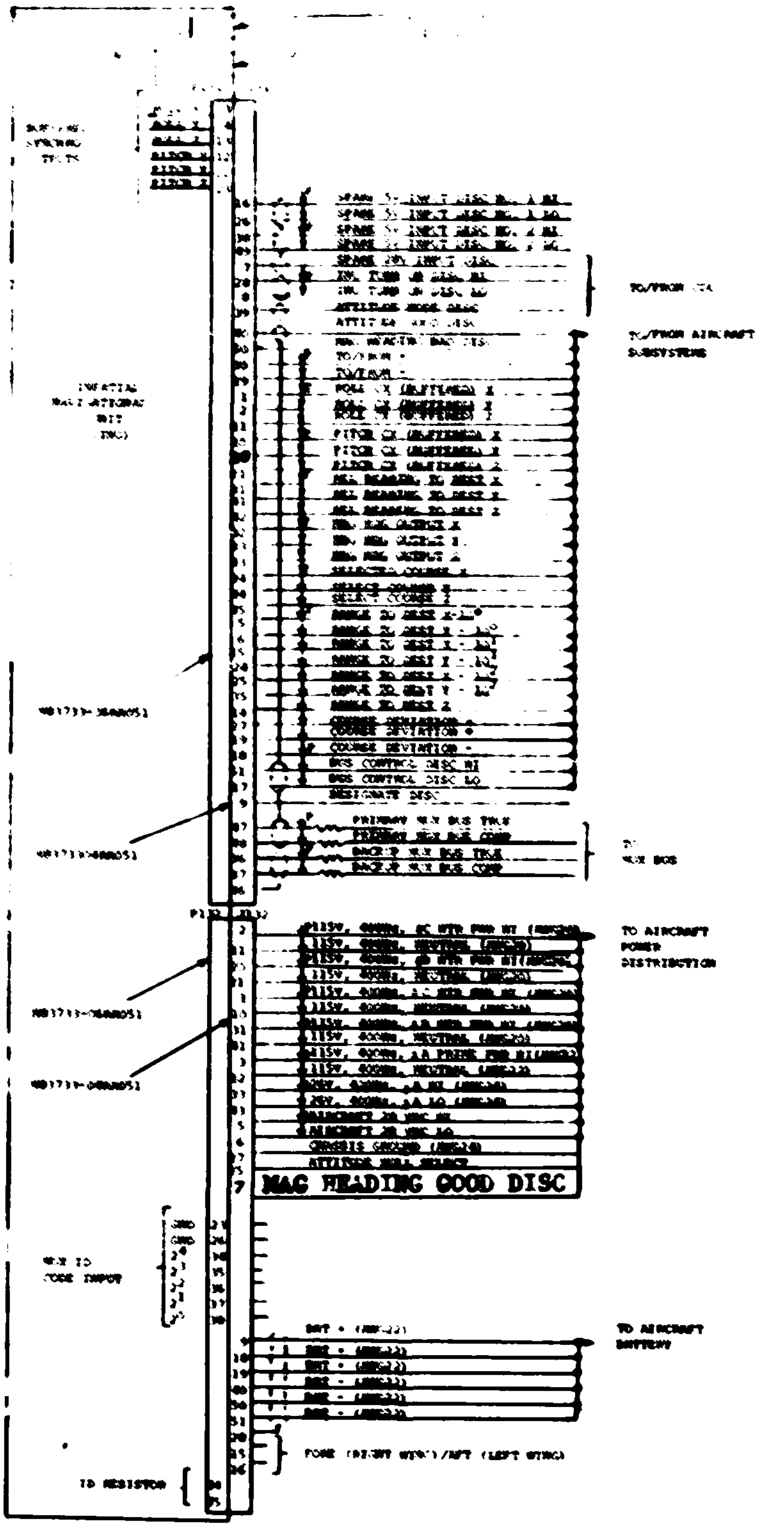

FIGURE 2 - ELECTRICAL INTERFACE

Table II

INU POWER CONSUMPTION SUMMARY

Vehicle Power	Starting	Running	Power Factor
115V, 400HZ 1 Phase A Prime Power (Aircraft Essential Bus)	340VA	280VA	0.8 minimum
115V, 400HZ 1 Phase B Heater Power	710VA (1)	70VA (2)	0.7 minimum (3)
115V, 400HZ 1 Phase C Heater Power	770VA (1)	70VA (2)	0.7 minimum (3)
26V, 400HZ 1 Phase (Supplied through transformer from Prime Power Phase)	40VA	35VA	0.5 minimum

(1) Includes full platform heater power
(2) Includes platform heater power at +35°F (1.67°C) cooling air
(3) Power factor is 0.95 minimum for starting VA

Table IIa

DC (Vehicle Battery) Power Consumption Summary

Battery Power   Running: 240 watts maximum (1)

(1) This is required only during loss of AC power to the INU.

NOTE: 28 VDC discrete signal power is required during AC powered operation.

3.2.4.1.1 Calibration Interval. The time between required calibrations shall be greater than 60 days.

3.2.4.1.2 Maintainability Definitions.

a. EMT. Either the summation of all corrective maintenance task times after each task time has been multiplied by its individual task frequency, divided by the summation of the task frequencies; or a statistically developed approximation of the above which is satisfactory to the procuring activity.

b. M_{max}. Time within which 90 percent of all corrective maintenance tasks can be accomplished.

c. Line Replaceable Unit (LRU). Any item whose flight line removal and replacement with a like serviceable item is considered the optimum corrective method for a specific higher indenture level item.

d. Shop Replaceable Unit (SRU). A subunit of an LRU which is normally removed and replaced to effect repair of the LRU.

e. Corrective Maintenance Task. The work performed as a result of a failure, for the purpose of restoring an item to a specific condition. The steps of a corrective maintenance task are: Fault Isolation, Fault Correction, Adjustment and Calibration and Checkout.

This includes the task of connecting and utilizing Support Equipment (SE) (if required) but excludes the tasks of positioning SE and obtaining spares resources.

f. Fault Correction. That step of a corrective maintenance task during which a failure is corrected by (1) repairing in place; (2) removing, repairing, and replacing a failed item; or (3) removing and replacing with a like serviceable item.

g. Fault Isolation. That step of a corrective maintenance task during which testing and analysis are performed on an item to locate a failure to the level of repair action.

h. Physical Adjustment and Calibration. That step of a corrective maintenance task during which manual adjustments or calibrations are made.

i. Checkout. That step of a corrective maintenance task during which performance of an item is verified to be restored to the full specification level.

j. Test Access Point. Any circuit access point, which is specifically designed into the SRU for functional input/output and/or test connection shall be considered a test access point (Examples - all connectors and test jacks). In-circuit component tie points, eyelets, and solder pads are not considered test access points.

3.2.4.2 Repair. Organizational maintenance on the INS, with the exception of display lamps, will be limited to the location, removal, and replacement of failed Line Replaceable Units (LRU). Intermediate shop maintenance will be limited to the location, removal and replacement of failed Shop Replaceable Units (SRU). The Equipment Repair Time (ERT) Median at the organizational level is specified to be 18 minutes and a M_{max} = 30 minutes* and includes the times to accomplish the following:

1. Location of a fault to an LRU.
2. Removal and replacement (not including vehicle access time).
3. Checkout of repair.

The Equipment Repair Time (ERT) median at the Intermediate Shop Level is specified to be 48 minutes and an M_{max} = 1.5 hours and includes the items to accomplish the following:

1. Verification of a fault in a LRU.
2. Location of a fault to a SRU.
3. Removal and replacement of a SRU(s).
4. Calibration (when required) of the LRU.
5. Checkout of the repair.

3.2.4.2.1 Organizational-Level Maintainability Requirements.

3.2.4.2.1.1 Equipment Handling. The equipment shall be designed and constructed such that "on-vehicle" maintenance can be performed in environments of any humidity up to 100 percent relative humidity, temperatures of -65°F (-54°C) to +160°F (71°C) and specified sand and dust by personnel wearing clothing, such as heavy gloves, required by the particular environment. Required maintenance, such as testing, removal, replacement and hookup shall be possible over this expected range of flight line environments with only external cleaning or wiping allowed.

The LRU shall be designed so that LRU handling or protective equipment is not needed for installation or for transport between

*Assuming free access to equipments as installed, i.e., the cockpit and any other necessary access door or panels are opened or removed.

the local maintenance and/or supply facility and the vehicle. The LRU mounting provisions for vehicle installation shall permit removal and replacement in five minutes or less by no more than one man using standard tools. Access and secure time shall not be included. The LRU weight limits shall be in accordance with the requirements of paragraph 5.9.11.3 of MIL-STD-1472.

3.2.4.2.1.2 Adjustments. "On-vehicle" adjustments, alignments or calibrations shall not be allowed for this equipment except as specified in 3.2.4.1.1. If any adjustments, alignments or calibrations are required at the intermediate level of maintenance except as specified in paragraph 3.2.4.1.1, these adjustments, alignments, or calibration devices shall not be accessible at the organizational level of maintenance. The INS shall require no periodic maintenance.

3.2.4.2.1.3 Boresighting. Mechanical boresighting of sensors shall not be required after replacement of the LRUs.

3.2.4.2.1.4 INU Mount. The INU mount shall provide for interchangeable installation of INUs without adjustment to retain INU boresight. In addition, boresight shall be retained through the environmental extremes specified in paragraph 3.2.5 and its subparagraphs.

3.2.4.2.2 Intermediate-Level Maintainability Requirements.

3.2.4.2.2.1 Packaging. Elements within LRUs shall be packaged to group functionally related elements within common SRUs as to minimize interconnections between SRUs and simplify fault isolation to a single SRU. All functional parts of the LRU shall be contained in separately removable, plug-in SRUs, except for the following:

a. Elapsed Time Meter
b. Connectors
c. Interconnecting Wiring
d. LRU Structure and Mounting Provisions
e. Panel Controls for which written approval by the procuring activity is obtained.
f. External Fault Indicators

3.2.4.2.2.2 Adjustments. SRUs shall be designed such that all replacement SRUs when installed in an LRU shall be immediately operable at design accuracy without requirements for continuity testing or functional adjustment or calibration of the replacement SRU or the LRU, except as approved in writing by the procuring activity. If such adjustments are approved, they should be distinctly labeled and accessible with the SRU installed in its normal position and without disturbing any other SRU or part.

3.2.4.2.2.3 Reversibility Restrictions. The equipment design and construction shall incorporate features such that it is mechanically and electrically impossible to install equipments incorrectly, and to attach cables, tubes, electrical plugs, and any other such items in an improper manner. Mechanically keyed mating, different size connectors, etc., shall be incorporated to eliminate all such possibilities. Shape of tubing tie-down provisions, color codes, labeling, etc., shall not be used as primary methods of satisfying this requirement.

3.2.4.2.2.4 Accessibility.

a. The equipment shall be designed and constructed such that it shall be possible to remove and replace any SRU without removing or disconnecting any other assembly in the LRU unless otherwise approved by procuring activity. If removal of the LRU structure (Re: covers) is required for access, such removal shall not affect electrical or mechanical alignment of the equipment nor shall the mechanical strength of the LRU be impaired to the point that damage to the equipment, its assemblies, subassemblies, or electrical harness will occur during normal bench handling of the LRU.

b. All SRU, assembly, and subassembly installation hardware and LRU covers which are required to be removed for SRU assembly or subassembly replacement shall employ captive-type hardware to prevent loss during normal field maintenance.

c. All LRU installation hardware shall be captive to prevent loss during vehicle maintenance.

d. The design and construction of the equipment shall provide ready access to test points and adjustments and for the replacement of items in the shop.

3.2.4.3 Built-In-Test (BIT) Function. Suitable BIT features shall be incorporated into the INS to provide both a failure detection function and a failure location function. The BIT shall include the following:

a. Self-Tests: That portion of BIT which operates continuously and automatically in conjunction with the normal item operation. Self-test is usually the major technique for fault detection.

b. Operator-Initiated: Supplemental tests initiated by the system operator or maintenance technician.

The results of these tests shall be available for display on the

CDU and appear on the NAV status word and the Attitude Good Discrete. Verification of repair shall be accomplished by these tests. In addition, the INU shall provide an external indication, located near the elapsed time meter (visible on the INU as installed), that the LRU has failed self-test. This external indicator shall be resetable upon passing self-test or SE test.

3.2.4.3.1 Failure Detection Function. The failure detection function shall provide an indication of equipment status. The failure detection function shall energize an advisory or caution indicator when equipment performance is below an acceptable level both while on the ground and in flight. This indicator shall be on either the operator's panel (control display unit) or at a remote location panel, or both, as the installation warrants. This Built-In-Test feature shall not require any auxiliary test devices external to the vehicle. The BIT circuitry shall automatically initiate a GO/NO-GO test upon equipment turn on and at periodic intervals unless it can be demonstrated that only on-demand, manually activated test modes are practical. Built-In-Tests shall minimize interface with the hardware functions.

3.2.4.3.1.1 Failure Detection Performance. The BIT capability to detect failures shall be that shown in Table III where (%FD) is percent failures detected and (%FFI) is percent false failure indications. In all cases (%FD) figures are minimum values whereas (%FFI) are not-to-exceed values.

3.2.4.3.2 Failure Location Function. The equipment shall incorporate features which shall locate a malfunction for the performance of organizational and intermediate level maintenance.

3.2.4.3.2.1 Organizational Level. The failure location function shall locate a failure to a Line Replaceable Unit (LRU) both on the ground and in the air with no special test equipment. The built-in-failure location function shall obviate the need for any auxiliary test devices for maintenance at this level. The failure location function shall be implemented such that a signal device(s) located on the LRU clearly indicates when a malfunction has occurred within. The device shall be such that it will hold the last test result (GO/NO-GO) if power is interrupted or removed and be clearly visible to the maintenance technician when the equipment is installed in the vehicle. If it is determined that operator participation can enhance fault location, such manually conducted tests (limited to keyboard entry, test switch positioning, checklist lookup, display observation, etc.) shall be permitted. Regardless of operator participation, the 18 minute requirement of paragraph 3.2.4.2 applies.

3.2.4.3.2.2 Intermediate Level. The failure location function shall

TABLE III

BIT REQUIREMENTS

PERCENT FAILURES DETECTED (% FD)	PERCENT FALSE FAILURE INDICATIONS (% FFI)
95	2

where: $(\%\ FD) = \dfrac{\text{Number of True Failure Indications}}{\text{Number of Total Failures}}$

$(\%\ FFI) = \dfrac{\text{Number of False BIT Indications}}{\text{Number of Total BIT Indications}}$

locate a failure to a Shop Replaceable Unit (SRU) within an LRU. The failure location function shall be implemented such that a signal device(s) located external or internal to the LRU clearly indicates where a malfunction has occurred. The device shall be such that it will hold the last tests result (GO/NO-GO) if power is interrupted or removed and be clearly visible to the maintenance technician when the LRU is either installed in the vehicle, removed from the vehicle, or when an initial LRU maintenance action such as removal of an inspection plate, cover, etc., occurs. The INU shall incorporate external test connectors for the use of test equipment which will further enhance fault location to the SRU level. Each SRU shall contain sufficient test points in a test connector and normal interface connector to allow for the utilization of automated test equipment.

3.2.4.3.2.3 Failure Location Performance. The system capability to isolate faults shall be that defined in the following paragraphs:

a. Organizational Level. The percent malfunctions isolated to the correct LRU, without ambiguity out of the total number of malfunctions, shall not be less than 95% when located automatically, nor less than 98% when the automatic fault location function is enhanced by operator intervention (paragraph 3.2.4.2).

b. Intermediate Level. The faults shall be isolated to the correct SRU(s) without ambiguity. The minimum acceptable requirements, when no external test equipment is used, are as follows:

1. In at least 75% of the cases, the fault shall be isolated to the correct SRU.

2. In at least 85% of the cases, the fault shall be isolated to the correct SRU and no more than one other SRU.

3. In all cases, the fault shall be isolated to the correct SRU and no more than three other SRUs.

When external test equipment is used, the minimum acceptable requirements are as follows:

1. In at least 90% of the cases, the fault shall be isolated to the correct SRU.

2. In at least 95% of the cases, the fault shall be isolated to the correct SRU and no more than one other SRU.

3. In all cases, the fault shall be isolated to the correct SRU and no more than two other SRUs.

3.2.5 Environmental Conditions. The INS shall deliver specified performance under any and all probable combinations of environmental conditions contained in MIL-E-5400R, paragraph 3.2.24 and its subparagraphs contained therein except as modified below.

3.2.5.1 Temperature. (Reference MIL-E-5400R, paragraphs 1.2 and 3.2.24.1.) The INS shall comply with Class 2X environmental requirements. The temperature of the air surrounding the INS (operational and non-operational conditions) may vary at a rate as high as 1.7°C per second within the applicable range. MIL-E-5400R, Table I, Column I for Class 2 equipment is modified to read "-40°C to +71 °C" and Columns IX and X are modified to read "-54°C to +95°C".

3.2.5.2 Altitude. (Reference MIL-E-5400R, paragraph 3.2.24.2.) The altitude (pressure) range is modified to include a steady state operation from 60,000 feet (1.04 psia) down to -1500 feet (15.1 psia), with intermittent operation from 60,000 feet (1.04 psia) up to 80,000 feet (.398 psia) for up to two minutes.

The pressure may vary at a rate as high as 0.6 psia per second. Operation at surrounding pressures from 1.04 to 0.44 psia shall be limited to two minutes per exposure.

3.2.5.3 Vibration. (Reference MIL-E-5400R, paragraph 3.2.24.5.) The INS shall provide normal performance as specified herein while subjected to a random vibration level as specified in Figure 6, herein, and when subjected to sinusoidal vibration levels specified by Curve IIIb. MIL-E-5400R.

3.2.5.3.1 Gunfire Vibration. Gunfire vibration for all vehicle installations shall be satisfied by the random vibration endurance level of Figure 6.

3.2.5.4 Rain. The INS shall meet the performance requirements of this specification with water dripping from the overhead structure or in rain as may occur when the access panels are left open. The 45 degree drip-proof requirements of MIL-STD-108E and Requirement 31 of MIL-STD-454E are applicable.

3.2.5.5 Solar Radiation. INS equipment mounted in the cockpit shall meet the performance requirements of this specification when subjected to solar radiation of an intensity and for the duration specified in MIL-STD-810C, Method 505.1, Procedure II.

3.2.5.6 Acoustical Noise. The INS shall meet the performance requirements of this specification when exposed to the acoustical environment specified in MIL-STD-810C, Method 5.5.2, Procedure I, Category A.

3.2.5.7 Flight Environment. The INS shall meet performance

requirements when subjected to the following flight environments (a, b, and c may occur in any combination):

PARAMETER	ACCELERATION	RATE	RANGE
a. Azimuth	± 6 rad/sec^2	± 3 rad/sec	Unlimited
b. Pitch	± 6 rad/sec^2	± 1 rad/sec	Unlimited
c. Roll	± 17.5 rad/sec^2	± 7 rad/sec	Unlimited

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d. Velocity ± 2500 fps in all axes

e. Latitude Unlimited in Navigate Mode

f. Altitude -1500 (-457.2m) to +60,000 (18288m) feet steady-state, +60,000 (18,288m) feet to +80,000 (24,384m) feet intermittent (2 minutes)

g. Altitude Rate Up to 150,000 (45,720m/min) ft/min

h. Linear Acceleration ± 12 g (3 axis)

3.2.5.8 Fluids. The INS shall withstand contact with the following fluids without damage or degradation of performance:

a. Water
b. JP-4 and JP-5 fuels (MIL-T-5624J)
c. Hydraulic Fluid (MIL-H-5606C)
d. Lubricating oil (MIL-L-7808G)
e. Coolants of the Fluorocarbon, silicon, silicate ester, and glyco families.

Fuel temperature will be within the range of -54°C to +93°C. Hydraulic fluid, lubricating oil, and coolant temperatures will be within the range of -54°C to +135°C. Drain holes shall be provided to prevent entrapment of fluids.

3.2.6 Transportability. The LRU(s) shall not require any special means of transportation. LRU(s) packing case(s) shall provide for safe, reliable, and efficient transport of units during shipment, by standard commercially available carriers.

3.3 Design and Construction. The INS shall be designed and constructed in accordance with MIL-E-5400R only to the extent

covered in paragraph 3.2.5, herein, and its subparagraphs except as modified below.

3.3.1 <u>Useful Life</u>. The INS shall have a useful life of not less than 15 years under any combination of operating and storage life, when the operational service life has not been exceeded.

3.3.2 <u>Operational Service Life</u>. The INS shall have an operational service life of not less than 10,000 hours under any natural combination of environmental conditions specified herein. Operational service life is defined as the total operating time between the start of operation and wear out. Wear out is defined as the point where overhaul or repair cost exceeds one-half of the replacement cost of the equipment.

3.3.2.1 <u>Storage</u>. The INU shall meet all requirements of this specification without component or part replacement, adjustment, or maintenance after being in storage for up to 18 months.

3.3.3 <u>Design Loads</u>. The INS shall be designed to meet the following normal vehicle operating limit and ultimate load factors.

3.3.3.1 <u>Normal Operating Load Factors</u>. The INS, when installed in the vehicle, shall meet all performance requirements of this specification during application of normal operating load factors between +12.0g (down) and -3.0g (up) and ±1.5g side acceleration and load factors of 3.0g forward and aft. Reference is to the 3 axes of the vehicle in all vehicle attitudes.

3.3.3.2 <u>Limit Load Factors</u>. The INS shall meet the performance requirements of this specification after application of the following limit loads:

1. ±2g side loads
2. 6g up load
3. 4g forward and aft load acting in combination with a down load of 13g.

Reference is to the 3 axes of the vehicle, in all vehicle attitudes. The equipment shall operate during the application of the load factors. There shall be no physical distortion or permanent set of the equipment after application of limit load factors.

3.3.3.3 <u>Ultimate Load Factors</u>. The INS shall withstand an ultimate load equal to 1.2 times the limit load factors with no failure of the structural supporting elements. Distortion and permanent set are permitted, but the INS shall remain in place

with no hazard during "power-on" operation of the INS. Normal navigation performance is not required during or after the application of ultimate loads.

3.3.4 Thermal Design. The INU shall be designed to be forced air cooled with air supplied by the vehicle environmental control system (ECS) at the conditions and flows described in subparagraphs 3.3.4.1 and 3.3.4.2. The equipment shall require cooling air only when operating, but shall not be adversely affected by receiving cooling air when not operating. The INU shall use cold plates/ heat exchangers so that none of the cooling air will come into contact with internal parts, circuitry, or connectors. The INU shall incorporate a temperature sensing device for thermal protection which will automatically shut-off the INU when critical temperature limits are exceeded. BIT shall monitor the overtemp condition, and shall be stored in the computer memory. The INU mount will be configured such that when the INU is removed from the vehicle, the air flow to the INU will be automatically shut off.

3.3.4.1 Cooling Air Conditions. The INU shall meet the performance requirements of this specification when exposed to the environmental conditions of paragraph 3.2.5 and when supplied with cooling air having the following characteristics:

a. Supply Air Temperature.
  (1) Minimum
    (a) Preflight and ground maintenance:
      Minus 51°C
    (b) Vehicle ECS, flight and ground:
      Minus 18°C (Normal)
      Minus 51°C (Abnormal)
  (2) Maximum:
    (a) Ground operation, including startup:
      Plus 49°C
    (b) Inflight Operation; all altitudes:
      Plus 38°C (Normal)
      Plus 49°C (Abnormal)

The INU shall be capable of satisfactory operation while being supplied air at the minimum and maximum abnormal limits for durations up to 30 minutes. The equipment shall sustain no permanent damage as a result of this exposure.

(3) Variation: During normal operation, the supply air temperature may vary at a rate as high as 1.7°C per second within the above ranges. During startup, the supply air temperature may vary at rates of as high as 5.5°C per second. The startup variation on a cold day may occur over the range of minus 51°C to plus 49°C. The startup variation on a hot day may occur over the range of plus 49°C to plus 100°C. The equipment shall sustain no damage as a result of exposure to startup transients.

b. Water Content. Each pound of cooling air may contain up to 210 grains of water, including up to 55 grains in the form of free water.

c. Sand and Dust. Each pound of cooling air may contain up to 0.1 grams of dust, the particle size not exceeding 50 microns.

3.3.4.2 Cooling Air Flow. The INU shall deliver specified performance when exposed to the normal range of environmental conditions of paragraph 3.2.5 and supplied with cooling air between 3.6 lbs/minute and the minimum flow rate curve shown on Figure 3. All INU alignments shall be performed with cooling air supplied between the minimum and maximum flow rate curves shown on Figure 3.

3.3.4.3 Resistance to Overcooling. The INU shall meet the performance requirements when receiving cooling air as specified in 3.3.4.2 herein. For interchangeability within the vehicle, the pressure loss of the delivered production units shall be as follows:

INU: 2 In H_2O nominal $\pm$ 10%

All measurements shall be made at a flow rate of 1.2 lb/min, at an inlet temperature of 27°C, and at 14.7 psia.

3.3.4.4 Pressurization. No equipment pressurization air will be supplied from the vehicle environmental control system.

3.3.4.5 Cooling Air Connectors. Equipment mounted in supplier furnished racks: The air inlet port for each INU shall be located so as to be compatible with a suitably located blind mating air plenum on the equipment rack. A separate, automatically actuated, shut-off device shall be provided on the rack to prevent the direct flow of cooling air from the rack blind mating plenum when the INU is removed from the rack. Flow restriction devices shall not be used in supplier furnished racks. The shut-off device shall be an integral part of the rack.

A single air inlet connector per MS-33660 shall be provided on the equipment rack for connection to the vehicle source of cooling air. The size, orientation and location of this connector shall be subjected to approval by the procuring activity. Suitable provisions shall be incorporated in the equipment rack to route cooling air from this connector to the INU air inlet port(s).

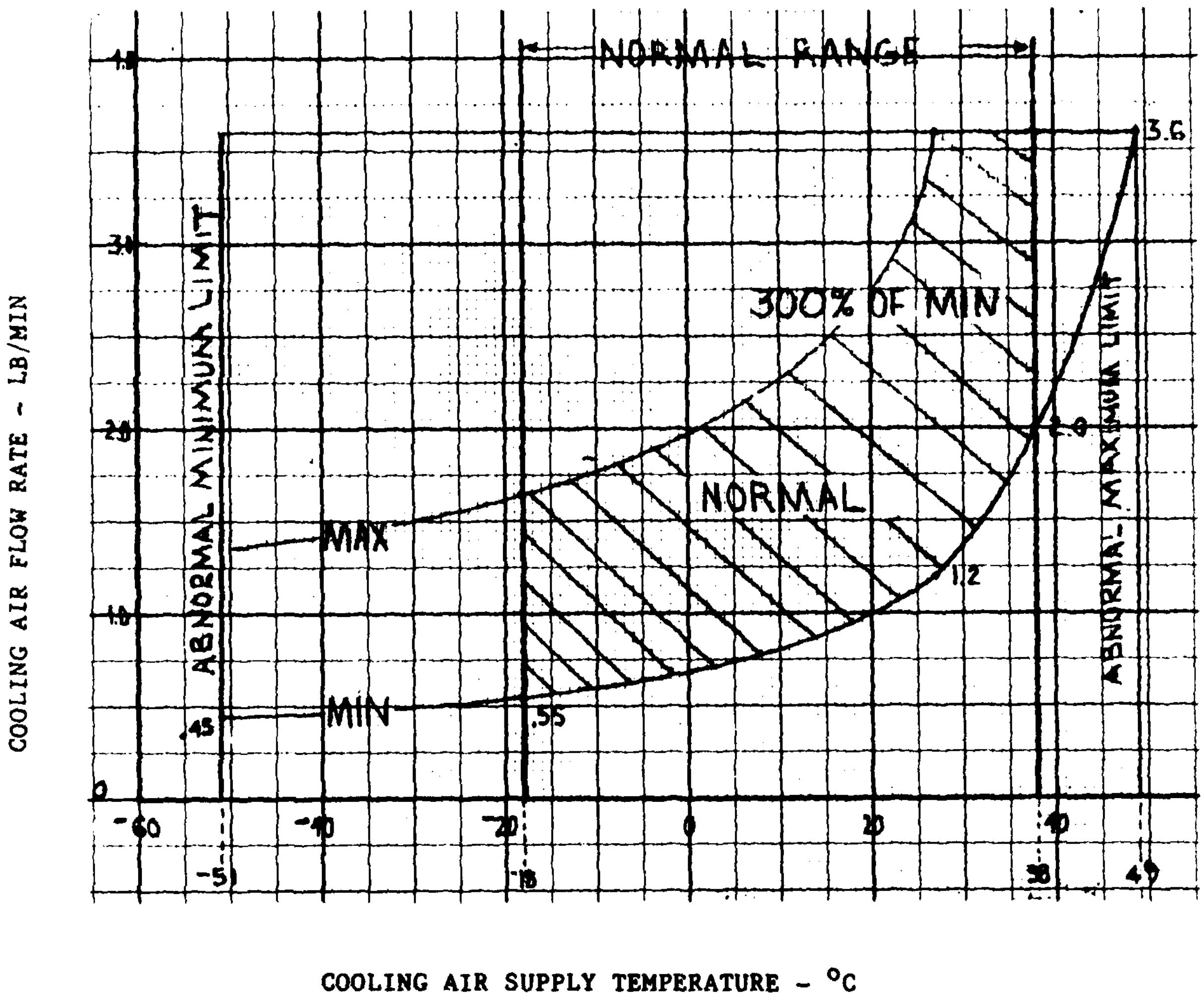


FIGURE 3 - COOLING AIR FLOW

3.3.5 Electromagnetic Interference (EMI). The INS system shall be designed using design handbook AFSC DH 1-4 as a guide. The generation and susceptibility to EMIC of all units of the INS shall be designed to comply with the EMI requirements of MIL-STD-461A, Notice 3, Methods CE01, CE02, CE03, CE04, CS01, CS02, CS06, RE02, RS02, and RS03.

3.3.5.1 Bonding. To assure compliance to MIL-B-5087B requirements, provisions for bonding clamps will be made between the equipment and its rack and between the rack and the vehicle structure. Provisions for the use of MS25083-2 bonding jumpers shall be made consistent with maintainability and reliability practices.

3.3.6 Nameplates and Product Marking. All parts and assemblies shall be marked in accordance with MIL-E-5400R, paragraph 3.1.16. A nameplate conforming to the requirements of MIL-STD-130D shall be permanently attached to each unit.

3.3.7 Workmanship. Workmanship shall be in accordance with MIL-STD-454E, Requirement 9.

3.3.8 Safety. The system safety criteria and requirements of MIL-STD-454E, Requirements 1 and 3, AFSC DH 1-6 and paragraphs 5.4 and 5.6 of MIL-STD-882 are applicable.

3.3.8.1 Safety Markings. Warnings/cautions and other markings shall be applied as necessary to aid personnel in avoiding potential hazards. Unless otherwise specified, such markings shall be consistent with MIL-STD-1472 except that warnings shall be white on conspicuous red, and cautions black on bright yellow with a black border.

3.3.9 Human Engineering. The design of the INS including the CDU, INS design specification manuals, and calibration procedures supporting this equipment shall be in accordance with MIL-STD-1472 requirements.

3.3.10 Elapsed Time Meter. The INU and CDU shall include a digital non-resettable, 9999 hours, elapsed time meter conforming to MS17322-10 and MIL-M-7793D. The meter shall be located on the front of the INU and shall be easily readable without removing the INU cover when mounted in the vehicle.

3.3.11 Connectors. Connectors shall conform to Requirement 10 of MIL-STD-454E. High density circular connectors shall conform to MIL-C-38999F, Series I. Low density circular connectors shall conform to MIL-C-83723C, Series 3. Rack and panel connectors shall conform to MIL-C-83733A.

3.3.12 Parts, Materials and Processes. The parts, materials and processes shall be in accordance with paragraph 3.1 of MIL-E-5400R and shall be subject to the approval of the procuring activity prior to their use.

3.3.12.1 Microcircuits. Microcircuits shall conform to Requirement 64 of MIL-STD-454E Class B devices. Non-standard microcircuits shall be screened to Method 5004.2, MIL-STD-883A, Class B requirement as a minimum. Plastic encapsulated microcircuits shall not be used.

3.3.12.2 Semiconductors. Semiconductors shall conform to requirement 30 of MIL-STD-454E, JANTX Class. Non-standard semiconductors shall be screened to equivalent JANTX requirements. Plastic encapsulated semiconductors shall not be used.

3.3.12.3 Passive Devices. Passive devices shall be selected from the Established Reliability (ER) specifications of MIL-STD-454E.

3.3.12.4 Non-Standard Parts. Non-standard parts require procuring activity approval prior to use. Non-standard parts shall be equal to or better than the same type military standard part and where possible shall be replaceable in the field by a military standard part. Parts used in tests must be in subsequent production, spares, etc.

3.3.13 Finishes and Colors. Equipment installed in the cockpit area shall be Lusterless Black, Color No. 37038 in accordance with FED-STD-595. Finish of all other equipment shall be Lusterless Gray Color No. 36231, in accordance with FED-STD-595.

3.3.14 Handles and Grasp Areas. Each unit shall be designed for ease of handling during installation and maintenance. Handle and grasp areas shall be in accordance with paragraph 5.9.11.5 of MIL-STD-1472.

3.3.15 Environmental Protection. Using personnel shall be protected from any adverse environmental conditions (e.g., temperature, shock, vibration and low pressure) in which the INS may be employed per paragraph 5.13 of MIL-STD-1472.

3.3.15.1 Toxicity. Personnel exposure to toxic air contaminants during INS operation, maintenance and training shall not exceed the ceiling values of OSHA Standard 1910.93.

3.3.15.2 High Voltage. Personnel exposure to high voltage during INS operation, maintenance and training shall be in accordance with requirement 1 of MIL-STD-454E.

3.3.16 Hazard Protection. Hazards which may cause adverse explosive, fire, mechanical, or biological effects on personnel during INS operation, test, maintenance and training shall be eliminated or controlled.

3.3.17 Switching Transients. Transients from switching within the equipment, whether automatically or manually controlled, shall be minimized by good equipment design.

3.3.18 Overload Protection. In addition to the overload protection requirements of 3.2.20 of MIL-E-5400R, the INS shall be protected from chain reaction failures, including those from external overloads (shorts) caused by grounding of external wiring during installation, test, or other causes. Insofar as practical, no damage to the INS shall result from open circuits or grounding of wiring external to the LRU.

3.3.19 Modular Design. The INS shall utilize modular space assignment and plug-in subassemblies to the greatest extent possible, consistent with requirements of this specification. Modules shall be designed on a functional block basis that permits simple functional checkout for location of malfunction and to facilitate repair. Modules which cooperate to achieve an identifiable subfunction shall be located together within a single unit of the equipment to the greatest possible extent. Potted or sealed modules which cause difficulty in basic part replacement shall be used only when required.

3.3.20 Personnel and Training. The design of the INS shall be such that its maintenance shall not require skills that exceed Level 5 as defined in AFM 39-1, Airman Classification Manual.

4.0 QUALITY ASSURANCE PROVISIONS.

4.1 General. The INS shall be subjected to verification in accordance with the requirements of this section to demonstrate compliance with this specification. The provisions of MIL-STD-810C as specified herein and the requirements of this section shall apply. When the two documents are in conflict, this specification shall govern. Compliance with the requirements of Section 3.0 shall be verified by inspection, analysis, demonstration, test, or a combination thereof as defined below:

a. Inspection. Inspection is defined as a visual verification that the equipment as manufactured conforms to the documentation to which it was designed.

b. Analysis. Analysis is defined as the verification that a specified requirement has been met through the technical evaluation of equations, charts, reduced data and/or representation data.

c. Demonstration. Demonstration is defined as a non-instrumented test where success is determined by observation alone. Included in this category are tests that require simple quantitative measurements such as dimensions, time to perform tasks, etc.

d. Test. Test is defined as the verification that a specified requirement is met by a thorough exercising of the applicable element under appropriate conditions in accordance with test procedures.

A record shall be made of all test data necessary to determine compliance with performance requirements. A cross reference of requirements to verification method is provided in Table IV.

4.1.1 Responsibility for Tests. All tests and inspections will be performed at the facilities specified in the contract statement of work.

4.1.2 Test Samples. The quantity and schedule for delivery of all test samples submitted for inspection and/or test will be specified in the contract statement of work.

4.1.3 Standard Conditions. The following conditions shall be used to establish normal functional performance characteristics:

a.	Ambient Room Temperature	$23° \pm 10°C$
b.	Surrounding Air Pressure	Prevailing lab conditions

TABLE IV

QUALITY ASSURANCE CROSS REFERENCE TABLE

SECTION 3.0

REQUIREMENT	REFERENCE	LABORATORY	AIRCRAFT
3.1	Item Description	4.2.1	-
3.1.1	Item Diagram	4.2.1	-
3.1.2	Interface Definition	4.2.3.2	-
3.1.2.1	Bus Control	4.2.3.2	-
3.1.2.1.1	Data Bus Redundancy	4.2.3.2	-
3.1.2.1.2	Bus Address	4.2.3.2	-
3.1.2.1.3	Status Word BIT Assignment	4.2.3.2	-
3.1.2.1.4	Mode Commands	4.2.3.2	-
3.1.2.1.5	Input/Output (I/O)	4.2.3.2	-
3.2	Characteristics	-	-
3.2.1	Performance	4.2.3.2	50.4.2
3.2.1.1	Position Accuracy	4.2.3.2	50.4.2
3.2.1.2	Velocity Accuracy	4.2.3.2	50.4.2
3.2.1.3	Reaction Times	4.2.3.2	50.4.2
3.2.1.4	Attitude Accuracy	50.4.1	50.4.2
3.2.1.5	Latitude Range/Vehicle Motion During Alignment	-	50.4.2
3.2.1.6	Performance Certification	50.4.1	50.4.2
3.2.1.7	INS Functions	4.2.3.2	50.4.2
3.2.1.8	Selectable Modes	4.2.3.2	50.4.2
3.2.1.9	Data Output	4.2.3.2	-

TABLE IV CONTINUED

3.2.2	Physical Characteristics	-	-
3.2.2.1	Size	4.2.3.1	-
3.2.2.2	Electrical Interface	4.2.3	-
3.2.2.3	Electrical Power	4.2.4.4	-
3.2.3	Reliability	-	-
3.2.4	Maintainability	4.2.7	
3.2.4.1	Design	4.2.7	
3.2.4.1.1	Calibration Interval	4.2.3	50.4.2
3.2.4.1.2	Maintainability Definitions	-	-
3.2.4.2	Repair	4.2.7	-
3.2.4.2.1	Organizational Level Maintainability Requirements	4.2.7	-
3.2.4.2.1.1	Equipment Handling	4.2.7	-
3.2.4.2.1.2	Adjustments	4.2.7	-
3.2.4.2.1.3	Boresighting	4.2.7	-
3.2.4.2.1.4	INU-Mount	4.2.7	-
3.2.4.2.2	Intermediate Level Maintainability Requirements	4.2.7	-
3.2.4.2.2.1	Packaging	4.2.7	-
3.2.4.2.2.2	Adjustments	4.2.7	-
3.2.4.2.2.3	Reversibility Restrictions	4.2.7	-

TABLE IV CONTINUED

3.2.4.2.2.4	Accessibility	4.2.7	-
3.2.4.3	Built-In-Test (BIT) Function	4.2.7	-
3.2.4.3.1	Failure Detection Function	4.2.7	-
3.2.4.3.1.1	Failure Detection Performance	4.2.7	-
3.2.4.3.2	Failure Location Function	4.2.7	-
3.2.4.3.2.1	Organizational Level	4.2.7	-
3.2.4.3.2.2	Intermediate Level	4.2.7	-
3.2.4.3.2.3	Failure Location Performance	4.2.7	-
3.2.5	Environmental Conditions	4.2.4.2	-
3.2.5.1	Temperature	4.2.4.2.1	50.4.2
3.2.5.2	Altitude	4.2.4.2.1	50.4.2
3.2.5.3	Vibration	4.2.4.2.3 4.2.4.2.12	50.4.2
3.2.5.3.1	Gunfire Vibration	4.2.4.2.15	-
3.2.5.4	Rain	4.2.4.2.5	-
3.2.5.5	Solar Radiation	4.2.4.2.9	-
3.2.5.6	Acoustic Noise	4.2.4.2.13	-
3.2.5.7	Flight Environment	4.2.3.2	50.4.2
3.2.5.8	Fluids	4.2.4	-
3.2.6	Transportability	4.2.1 4.2.7	-

TABLE IV CONTINUED

3.3	Design and Construction	4.2.1	-
3.3.1	Useful Life	4.2.1 4.2.7	-
3.3.2	Operational Service Life	4.2.1 4.2.7	-
3.3.2.1	Storage	4.2.1 4.2.7	-
3.3.3	Design Loads	-	-
3.3.3.1	Normal Operating Load Factors	50.4.1.16	-
3.3.3.2	Limit Load Factors	4.2.4.2.11	-
3.3.3.3	Ultimate Load Factors	4.2.4.2.14	-
3.3.4	Thermal Design	4.2.4.2.4	-
3.3.4.1	Cooling Air Conditions	4.2.4.2.4	-
3.3.4.2	Cooling Air Flow	4.2.4.2.4	-
3.3.4.3	Resistance to Over-Cooling	4.2.4.2.4	-
3.3.4.4	Pressurization	4.2.4.2.4	-
3.3.4.5	Cooling Air Connectors	4.2.3.1	-
3.3.5	Electromagnetic Interference (EMI)	4.2.4.3	-
3.3.5.1	Bonding	4.2.4.3	-
3.3.6	Nameplates and Product Marking	4.2.1	-
3.3.7	Workmanship	4.2.1	-
3.3.8	Safety	4.2.2	-

TABLE IV CONTINUED

3.3.8.1	Safety Markings	4.2.1	-
3.3.9	Human Engineering	4.2.1	-
3.3.10	Elapsed Time Meter	4.2.1	-
3.3.11	Connectors	4.2.3.1	-
3.3.12	Parts, Materials and Processes	4.2.1	-
3.3.12.1	Microcircuits	4.2.1	-
3.3.12.2	Semiconductors	4.2.1	-
3.3.12.3	Passive Devices	4.2.1	-
3.3.12.4	Non-Standard Parts	4.2.1	-
3.3.13	Finishes and Colors	4.2.1	-
3.3.14	Handles and Grasp Areas	4.2.1	-
3.3.15	Environmental Protection	4.2.1	-
3.3.15.1	Toxicity	4.2.1	-
3.3.15.2	High Voltage	4.2.1 4.2.4.4	-
3.3.16	Hazard Protection	4.2.1	-
3.3.17	Switching Transients	4.2.1 4.2.4.4	-
3.3.18	Overload Protection	4.2.4.4	-
3.3.19	Modular Design	4.2.3.1	
3.3.20	Personnel and Training	4.2.1	

c.	Humidity	Room ambient up to 90% relative humidity
d.	Input Power	AC: 113 ± 5 V, 400 ± 20 Hz, 3∅ DC: 28+0.5 V, -4.0V
e.	Cooling Air	
	Cooling Air Temperature	17 ± 10°C
	Cooling Air Humidity	Up to 95% relative humidity
	Cooling Air Flow	Per Figure 3, Cooling Air Flow requirements

4.1.4 Test Apparatus Accuracy. All test equipment shall comply with the requirements of MIL-STD-810C, paragraph 3.1.3.

4.1.5 Failure Criteria. A failure is defined to be a complete malfunction or a reduction in the performance of the INU below the requirements of this specification which was corrected by repair, replacement, or calibration of any part of the INU. A failure must be disregarded if it can be convincingly proven that it was caused by abnormal external events or human errors in operating and handling equipment. The following criteria shall constitute a failure:

a. The failure symptoms must be repeatable.

b. Unscheduled calibrations, unscheduled maintenance and/or unscheduled reprogramming are failures if they occur within 60 days of the previous calibration.

c. Monitored functional parameters that deviate beyond acceptable specification limits shall constitute a failure.

d. Failures can be catastrophic or structural in nature.

e. Deterioration, corrosion, or change in tolerance limits of any internal or external parts which prevent the test item from meeting operational service or maintenance requirements constitute a failure.

4.1.6 Test Sample Refurbishment. The test samples which have been subjected to testing and exhibit deterioration shall not be delivered on contract until they have been refurbished. The wear items to be replaced shall be determined by agreement between the contractor and the procuring activity. Test samples which have been subjected to safety of flight crash loads shall not be delivered on contract.

4.1.7 <u>Functional Tests</u>. Functional tests are required during acceptance, product verification, and pre- and post-qualification tests. The following criteria shall apply to the attitude and navigation accuracy parts of these tests:

a. Attitude Test. The attitude test shall start with the INU stabilized at room temperature with all power off. The INS will be turned on and allowed to complete a full alignment before entering the navigation mode. Following the alignment sequence, the INU case will be incremently positioned in azimuth, pitch, roll and compound pitch and roll. The INS output data will be allowed no more than 5 seconds stabilization time before a comparison of case position to output data position in all three axes is recorded. A failure is defined as any difference in azimuth, pitch, or roll by more than 0.25 degree between case orientation and output data orientation.

b. Navigation Test. The navigation test shall consist of two in place navigation runs at two different headings. Each navigation run shall start with the INS stabilized at room temperature with all power off. The INS will be turned on and allowed to complete a full alignment before entering the navigation mode. Radial position error shall not exceed .5 NM during the first 15 minutes of navigation and shall not exceed 2.0 NM per hour during the remainder of the test. The velocity error in either horizontal axis shall not exceed the following limits: 0.25 fps at the instant the navigation mode is entered, 8.0 fps peak to peak oscillation, and 2.5 fps RMS for the first two hours of the test based on velocity data recorded at five minute intervals.

(1) The first run of the navigation tests shall consist of a stationary run of at least 90 minutes after entry into the navigation mode. The test will be performed at a case heading of North.

(2) The second navigation run shall consist of a stationary run of at least 90 minutes after alignment. This run shall be accomplished at an East case axis heading.

4.1.8 Performance Checks. The procedures, test parameters, etc required to accomplish performance checks shall be submitted to the procuring activity for review and approval prior to the commencing any tests.

4.2 Test Classification. Inspection and testing of the INS will be classified as follows:

a. Examination of Product - see paragraph 4.2.1.
b. Performance Certification Test - see paragraph 4.2.2.
c. Acceptance Test - see paragraph 4.2.3.
d. Qualification Test - see paragraph 4.2.4.
e. Combined Environments Test - see paragraph 4.2.5.
f. Production Verification Test - see paragraph 4.2.6.
g. Maintainability Demonstration - see paragraph 4.2.7.

4.2.1 Examination of Product. Each test item submitted shall be given a thorough visual and mechanical inspection to determine that the quality of material, workmanship and design is in compliance with the requirements of this specification.

4.2.2 Performance Certification Test. This series of laboratory and flight tests shall be conducted at CIGTF in accordance with the procedures outlined in Appendix V.

4.2.3 Acceptance Test. Each deliverable item shall be subjected to the following acceptance tests.

4.2.3.1 Examination of Product. Each deliverable item shall be examined to determine conformance with the applicable drawing and all requirements of this specification for which there is not specific test. In addition, the requirements of paragraph 4.2.1 of this specification shall apply.

4.2.3.2 Functional Tests. The functional characteristics of the equipment shall be measured in accordance with the acceptance test procedures and the data recorded. Any equipment found out of tolerance shall be rejected. The acceptance test procedures shall be submitted to and approved by the procuring activity prior to use in formal testing.

4.2.3.3 Rejection and Retest. Equipment which has failed to meet the acceptance tests of this specification shall be rejected. Final acceptance of rejected equipment shall not be made until it is determined that the item meets all acceptance test requirements. The equipment may be reworked or have parts replaced to correct the cause of rejection. Full particulars concerning the rejection and action to correct the fault shall be submitted with the equipment.

4.2.3.4 Test Conditions. Unless otherwise specified, all acceptance tests shall be conducted under the standard conditions of 4.1.3.

4.2.4 Qualification Tests. This test series shall be used to certify that the INS complies with the requirements of this specification. The location(s) where testing will be conducted and the required surveillance of tests shall be as stated in the contract.

a. Test Samples. The test samples shall consist of models representative of production equipment. The quantity to be subjected to qualification testing shall be specified in the contract.

b. Certification. Certification of the satisfactory completion of qualification tests shall be submitted to the government as required by the contract.

c. Test Sequence. The following sequence of tests shall be used to accomplish the qualification test series:

(1) Prequalification Acceptance Test - see paragraph 4.2.4.1.

(2) Environmental Tests - see paragraph 4.2.4.2.
(3) Electromagnetic Interference Tests - see paragraph 4.2.4.3.
(4) Electrical Power Test - see paragraph 4.2.4.4.
(5) Post-Qualification Functional Test - see paragraph 4.2.4.5.

4.2.4.1 Prequalification Acceptance Test. A complete acceptance test in accordance with paragraph 4.2.3 shall be performed on each test item prior to the start of the environmental, EMI, etc. tests in this series.

4.2.4.2 Environmental Tests. Environmental Tests shall be in accordance with MIL-STD-810C except as modified herein. The equipment shall be subjected to performance checks (paragraph 4.1.8) before, during (unless otherwise specified), and after each environmental test to determine satisfactory operation. The equipment shall sustain neither physical damage nor performance degradation either during or as a result of exposure to these tests.

If Combined Environments Testing (CET) is performed as specified in paragraph 4.2.5 of this specification, then subparagraphs 4.2.4.2.1 through 4.2.4.2.3 may be optional if contractually specified, otherwise the following testing shall be accomplished.

4.2.4.2.1* Temperature and Altitude. Test in accordance with MIL-STD-810C, Method 504.1, Procedure I (Category 6) for the temperature and altitude requirements of paragraph 3.2.5.1 and 3.2.5.2 herein.

4.2.4.2.2 Humidity Test. Test in accordance with MIL-STD-810C, Method 507.1, Procedure I.

4.2.4.2.3 Random Vibration. Test in accordance with MIL-STD-810C, Method 514.2 for the performance and endurance levels as specified in Figure 6 herein. The INS shall be tested for one (1) hour in each of its three (3) orthogonal axes during both the performance and endurance tests. During the performance test the INS shall demonstrate the requirements of paragraph 3.2.1. However, during the endurance test, the INS shall be in the NAV mode, and system performance sha'l be checked by functional testing upon completion of the test. While the functional tests are being performed, the INS shall be mounted with respect to its vehicle installed axis and shall not be subjected to vibration.

* - Represents tests that shall be performed on test articles prior to the first flight in any vehicle (Safety of Flight).

4.2.4.2.4 Cooling Air. The purpose of these tests is to insure the INS meets the performance requirements when any LRU designed to be forced air cooled is supplied with cooling air over the specified design range.

a. Air Flow and Pressure Loss. The system will be operated in the maximum heat dissipating mode. The cooling air temperature and flow rate shall be adjusted to the specified conditions. The total air pressure loss through the LRU shall be compared to the specified maximum allowable loss.

b. Overcooling. The INS shall be stabilized at minus $40 \pm 2^{\circ}C$ at ambient pressure. The cooling air shall be adjusted to minus $18^{\circ}C$ at three times the minimum specified flow rate. The INS shall be turned on, aligned and operated in the navigate mode for 84 minutes. No degradation of performance shall be allowed. The test shall be repeated with operation in the navigate mode for 30 minutes but with cooling air temperature of minus $51^{\circ}C$, for which degraded performance is allowed.

c. Undercooling. The INS shall be stabilized at $71 \pm 2^{\circ}C$ at ambient pressure. The cooling air shall be adjusted to $38^{\circ}C$ at the minimum specified flow rate. The INS shall be turned on, aligned and operated in the navigate mode for 84 minutes. No degradation of performance shall be allowed. The test shall be repeated with operation in the navigate mode for 30 minutes but with cooling air at $49^{\circ}C$, for which degraded performance is allowed.

4.2.4.2.5 Rain. Test in accordance with MIL-STD-810C, Method 506.1, Procedure II.

4.2.4.2.6 Sand and Dust. Test in accordance with MIL-STD-810C, Method 510.1, Procedure I.

4.2.4.2.7 Fungus. Vendor certification shall be accepted for well established materials. However, the government reserves the right to test the INS in accordance with the fungus test Method 508.1 of MIL-STD-810C, Procedure I.

4.2.4.2.8 Salt Fog. Test in accordance with MIL-STD-810C, Method 509.1, Procedure I.

4.2.4.2.9 Solar Radiation. Test in accordance with MIL-STD-810C, Method 505.1, Procedure II, for cockpit instruments only.

4.2.4.2.10* Explosive Atmosphere. Explosion proof testing on all INS equipment which is not hermetically sealed or which is not enclosed in pressurized or sealed containers shall be conducted in accordance with MIL-STD-810C, Method 511.1, Procedure I, modified to include 60,000 feet simulated altitude in paragraph 3.1.2 of Procedure I.

4.2.4.2.11 <u>Linear Acceleration - Limit Load</u>. The purpose of this test is to verify satisfactory performance after the application of limit loads.

a. The test shall be performed with a system mounted on a centrifuge.

b. The INS shall be prepared in accordance with pre-test performance requirements, paragraph 50.3.2.1. Perform gyrocompass alignment and conduct ten minutes of static navigation.

c. The system will be maintained in the navigate mode during acceleration and for 84 minutes after each acceleration. Record system horizontal position and velocity once per minute for each test.

d. With the case oriented so that lateral loading is placed on the case by the centrifuge when it rotates, impose a steadily increasing acceleration on the test item peaking at 2 g's. Total test time is limited to five minutes and the angular rate should not exceed 3 radians/second during the test.

Rotate the case 180° about a vertical axis, then impose a steadily increasing acceleration on the test item peaking at 2 g's. Time and angular rate limitations are as above.

e. Orient the case to simulate a vehicle in vertical flight that is experiencing negative g's. Impose a steadily increasing g-load on the case peaking at 6 g's. Total test time is limited to 7 minutes and the angular rate should not exceed 7 radians/second.

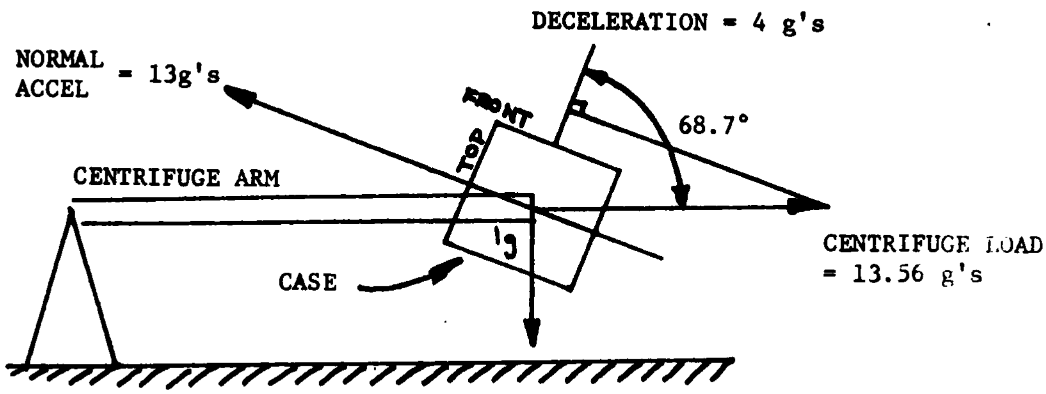
f. Orient the case as shown in Figure 4 to simulate a vehicle experiencing a 13 g normal acceleration with a simultaneous 4 g deceleration (forward load). Impose a steadily increasing centrifugal load peaking at 13.56 g's so that down and forward loads are 13 g's and 4 g's respectively. Total test time is limited to 10 minutes and the centrifuge angular rate should not exceed 7.51 radians/second (equivalent to 7 radians/second about roll axis and 2.73 radians/second about the yaw axis). Rotate the case 180° with respect to the case vertical axis, then impose a steadily increasing centrifugal load peaking at 13.56 g's. Time and angular limitations are as above.

g. A time history of horizontal position and velocity errors indicated by the system during each test will be plotted. These results will be compared with the specified position and velocity accuracy requirements.

FREE BODY EQUATIONS

$$\text{DECELERATION} = \left[\begin{array}{l}\text{CENTRIFUGE}\\ \text{LOAD}\end{array}\right] \text{COS } 68.7° \ -\text{SIN } 68.7°$$

$$\begin{array}{l}\text{NORMAL}\\ \text{ACCEL}\end{array} = \left[\begin{array}{l}\text{CENTRIFUGE}\\ \text{LOAD}\end{array}\right] \text{SIN } 68.7° \ +\text{COS } 68.7°$$



LINEAR ACCELERATION

4 g DECELERATION ACTING WITH 13 g's NORMAL ACCEL.

FIGURE 4

4.2.4.2.12* Sinusoidal Vibration. Test in accordance with MIL-STD-810C, Method 514.2, Procedure I, Figure 514.2-3 Level M.

4.2.4.2.13 Acoustic Noise. Test in accordance with MIL-STD-810C, Method 515.2, Procedure I, Category A.

4.2.4.2.14* Shock. Test in accordance with MIL-STD-810C, Method 516.2, Procedures I, II, III and V.

4.2.4.2.15 Gunfire Vibration. Testing of this requirement will have been accomplished previously under the test guidelines established in paragraph 4.2.4.2.3.

4.2.4.2.16 Toxicity. Materials in the equipment which appear in Table G-1, G-2 and G-3 of OSHA Standard 1910.93 will be identified. Designs containing such materials are limited to the ceiling values on eight-hour time weighted averages given in the above tables. Tests will be conducted to determine material concentrations wherever analyses are inclusive.

4.2.4.3 Electromagnetic Interference (EMI Tests). Compliance with the applicable requirements of MIL-STD-461A, Notice 3 shall be demonstrated by testing of the INS in accordance with MIL-STD-462, Notice 2, test methods CE01, CE02, CE03, CE04, CS01, CS02, CS06, RE02, RS02, and RS03.

4.2.4.4 Electrical Power Test. The system shall be prepared in accordance with the performance of test requirements (MIL-STD-810C, paragraph 3.2). Outputs of velocity and attitude will be recorded during power tests.

a. Normal and Emergency AC Power. The INS shall be operated in the navigate mode at the voltages of 104, 113, 108, 113, 118, 113, and 122 for a period of not less than 10 minutes for each voltage value.

b. AC Power Factor. The INS individual phase power factors shall be determined with the system operating in the navigate mode and shall meet the limits of Table II of this specification.

c. AC Frequency. The INS shall be operated in the navigate mode at 400 Hz, 420 Hz, 400 Hz, 380 Hz and 400 Hz for a period of not less than 10 minutes for each frequency.

d. AC Transients. The INS shall be tested for AC transient sensitivity as specified in MIL-STD-704A, limits 1 and 4 of Figure 3. The INS shall be operated in the navigate mode for a period of not less than 10 minutes following each transient.

4.2.4.4.1 DC Power.

a. Normal and Emergency Levels. The INS shall be operated in the navigate mode at the normal aircraft power distribution 28 volt DC line voltages of 16, 28, 24, 28, 22.5, 28, 30 and 28 VDC for a period of not less than 10 minutes for each voltage value.

b. DC Transients. The INS shall be tested for DC transient sensitivity by applying transient voltages on the normal aircraft power distribution 28 volt DC line, as specified in MIL-STD-704A, limits 1 and 4 of Figure 9. The INS shall then be operated in the navigate mode for a period of not less than 10 minutes following each transient.

4.2.4.4.2 Vehicle Battery Power.

a. Battery Steady State Voltage. With the normal AC and DC power inputs removed, the INS shall be operated in the navigate mode with vehicle battery power at voltages of 16.5 volts and 29.5 volts. Operation shall be for a period of not less than 10 minutes for each voltage.

b. Battery Transient Voltage. With the normal AC and DC power inputs removed, and with the INS operating in the navigate mode with vehicle battery power applied, the INS shall be tested for sensitivity to the battery transient voltages of limits 5 and 6 of Figure 9, MIL-STD-704A. The INS shall then be operated in the navigate mode for a period of not less than 10 minutes following each transient.

4.2.4.4.3 Power Consumption. The AC and Vehicle Battery DC inputs shall be monitored and recorded. The Vehicle Battery DC power shall not exceed the limits shown in Table IIa. The Vehicle AC power (startup and running) shall not exceed the limits shown in Table II.

4.2.4.5 Post-Qualification Functional Test. A post-qualification functional test shall be performed in accordance with the procedures of paragraph 4.2.3.2.

4.2.5 Combined Environmental Test (CET). The purpose of the CET is to evaluate system design by obtaining engineering failure data while the system is operating in a simulated service environment. Three types of environments will be simulated; artic, desert, and tropic . Altitude, temperature, relative humidity, and vibration shall be varied in accordance with the requirements of this specification while the INS is operating in the navigate mode. Only the tropic "flights" shall require humidity control. All normal INS outputs shall be monitored for compliance with the requirements of this specification during all test cycles.

4.2.5.1 Test Samples. The quantity and configuration of the test samples shall be as specified in the contract.

4.2.5.2 Test Procedure. Each test cycle shall consist of a 65 minute temperature soak, a simulated flight, a 15 minute null, and a simulated flight for a total of 480 minutes. The total test consists of 100 hours (30 simulated flights) in accordance with the schedule as shown in Table V. The profiles for temperature, altitude, relative humidity (tropic only) and vibration are shown in Figures 5 and 6A. A detailed description of the profiles is provided in Table VI. For each test condition of the CET, the INS shall be provided with the cooling air equivalent to that as specified in paragraph 3.3.4 herein.

4.2.6 Production Verification Test (PVT). Production verification tests shall be conducted in accordance with the requirements specified

TABLE V COMBINED ENVIRONMENTS TEST

CYCLE	TEMPERATURE SOAK (°C)	TYPE CYCLE
1	71	Desert
2	50	Desert
3	50	Tropic
4	50	Desert
5	50	Desert
6	50	Tropic
7	4	Arctic
8	4	Arctic
9	4	Arctic
10	-40	Arctic
11	4	Arctic
12	4	Arctic
13	50	Desert
14	50	Desert
15	50	Tropic

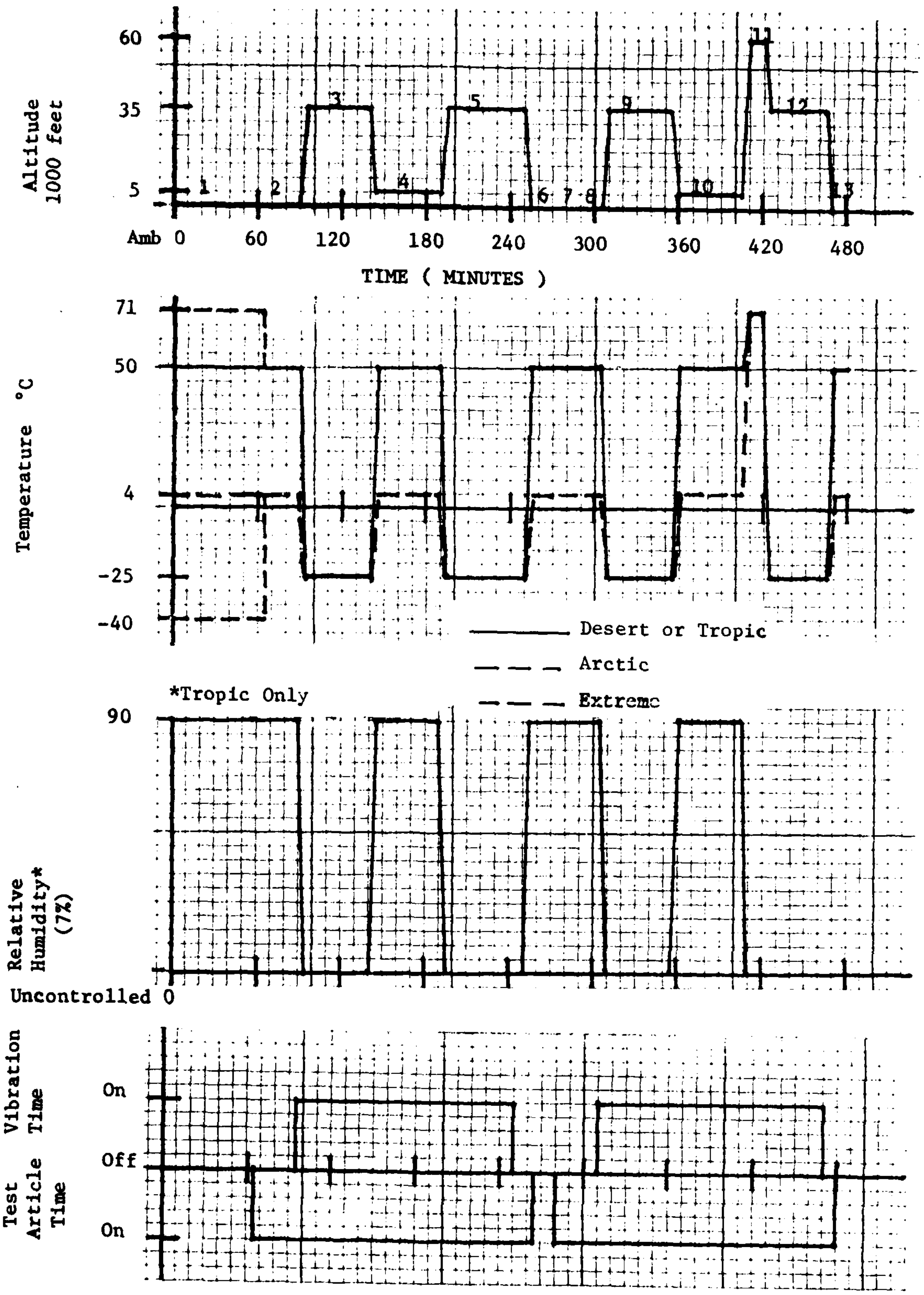


FIGURE 5 - COMBINED ENVIRONMENT TEST PROFILES

	Step Number	Time Interval (Min)	Altitude (1000 ft)	Desert Temp °C	Desert Humidity % RH	Arctic Temp °C	Arctic Humidity % RH	Tropic Temp °C	Tropic Humidity % RH	Vibration G^2/Hz
Soak Temp	1A	0 to 65	amb	71		-40		--	--	0
	1B	0 to 65	amb	50		4		50	>90	0
Simulated Flight	2	65 to 90	amb	50		4		50	>90	0
	3	95 to 140	35	-25		-25		-25	Uncontrolled	0.02
	4	145 to 190	5	50		4		50	>90	0.02/0.04*
	5	195 to 250	35	-25		-25		-25	Uncontrolled	0.02
	6	255 to 265	amb	50		4		50	>90	0
Off		265 to 280	amb	50	Uncontrolled	4	Uncontrolled	50	>90	0
Simulated Flight	8	280 to 305	amb	50		4		50	>90	0
	9	310 to 355	35	-25		-25		-25	Uncontrolled	0.02
	10	360 to 405	5	50		4		50	>90	0.02/0.04*
	11	410 to 420	60	70		70		70	Uncontrolled	0.02
	12	425 to 465	35	-25		-25		-25	Uncontrolled	0.02
	13	470 to 480	amb	50		4		50	Uncontrolled	0

* See footnotes on Figure 6A.

TABLE VI - COMBINED ENVIRONMENT TEST PROFILES

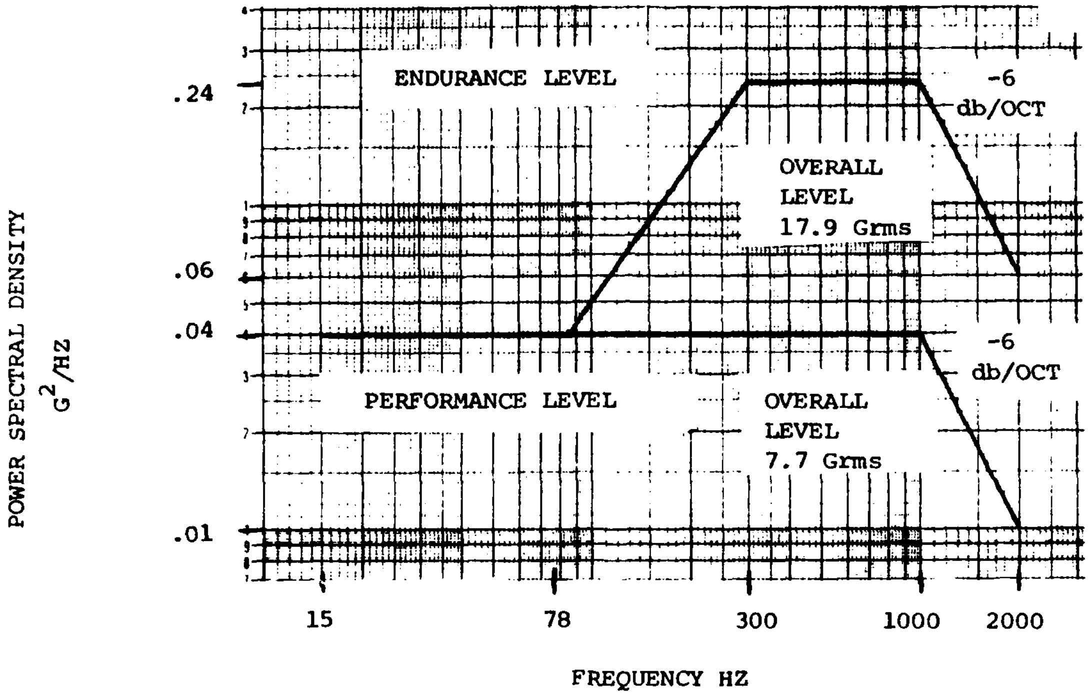
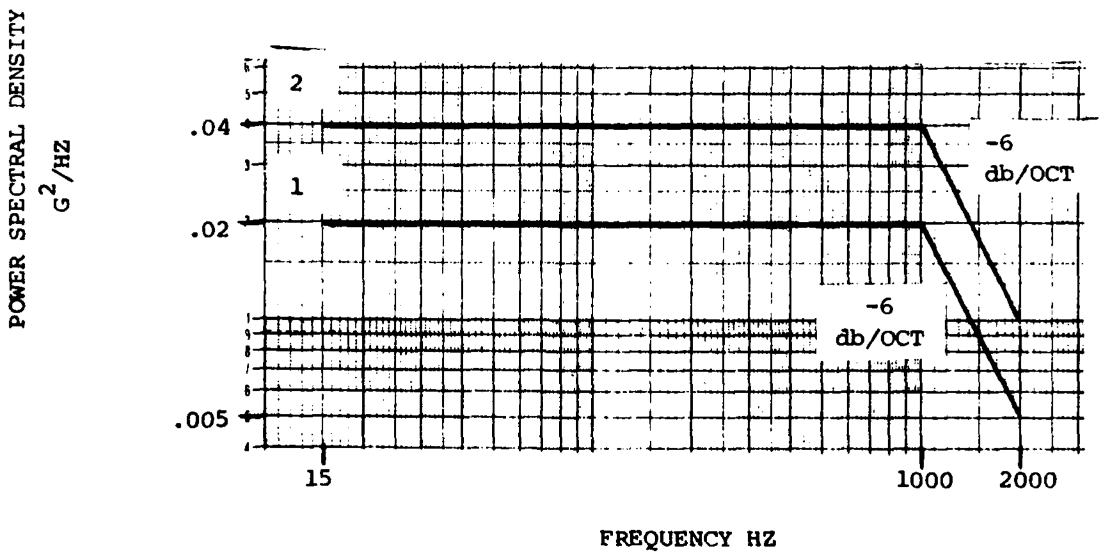


FIGURE 6 - RANDOM VIBRATION TEST LEVEL



NOTES:

1. Curve 1 to be run during all INS on times except for 5 minutes out of each 5,000 ft. altitude segment of the flight profile (Reference Figure 5).

2. Curve 2 to be run for 5 minutes during each 5,000 ft. altitude segment of the flight profile (Reference Figure 5) for a total test time of 10 min per 8 hr CET cycle.

FIGURE 6A - CET RANDOM VIBRATION TEST LEVELS

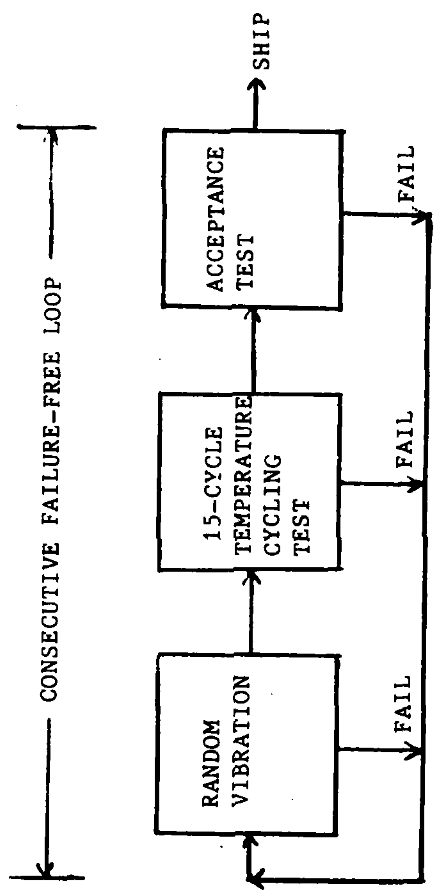


FIGURE 7 - PRODUCTION VERIFICATION TEST SEQUENCE

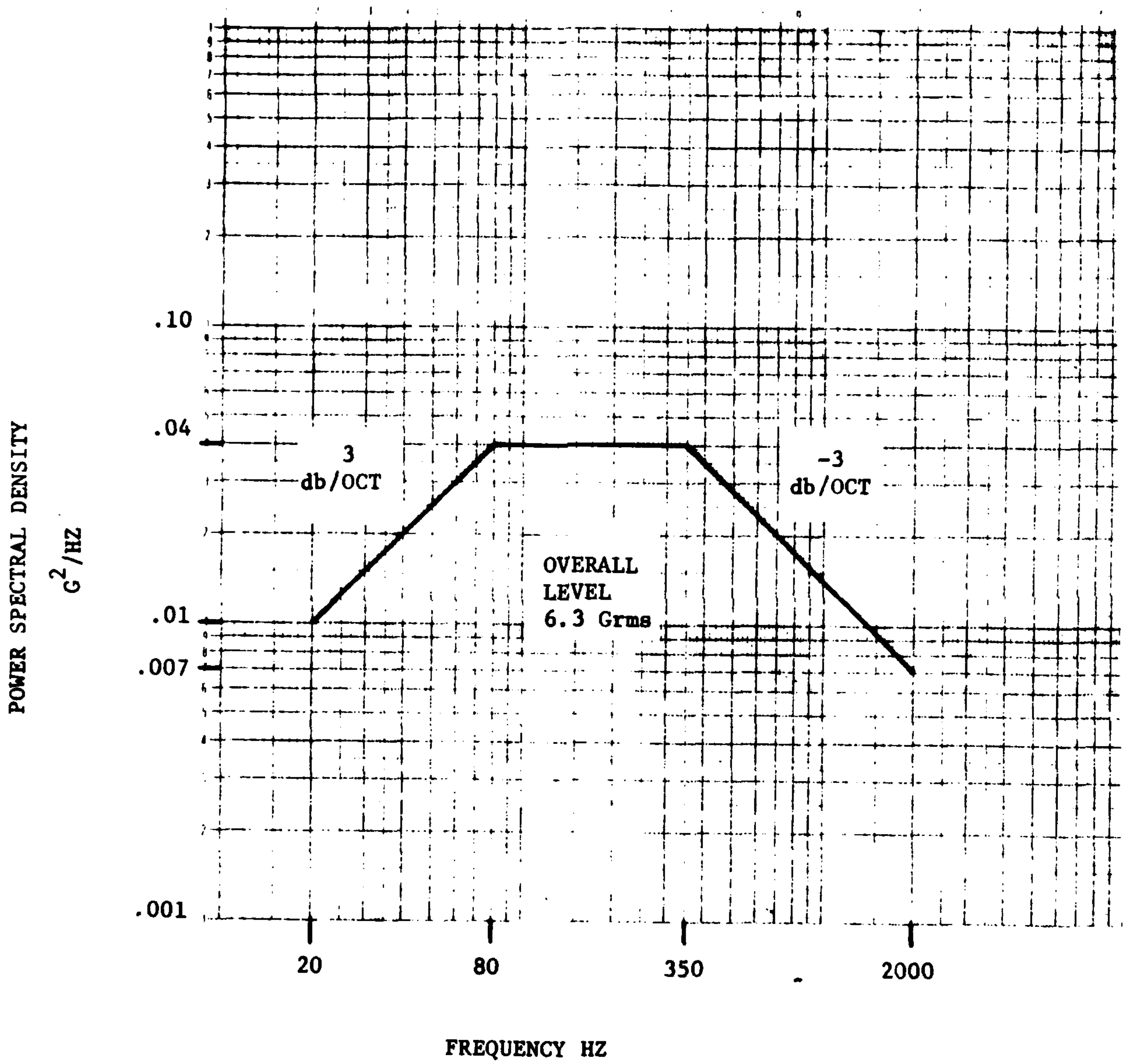


FIGURE 8 - PVT RANDOM VIBRATION SPECTRUM

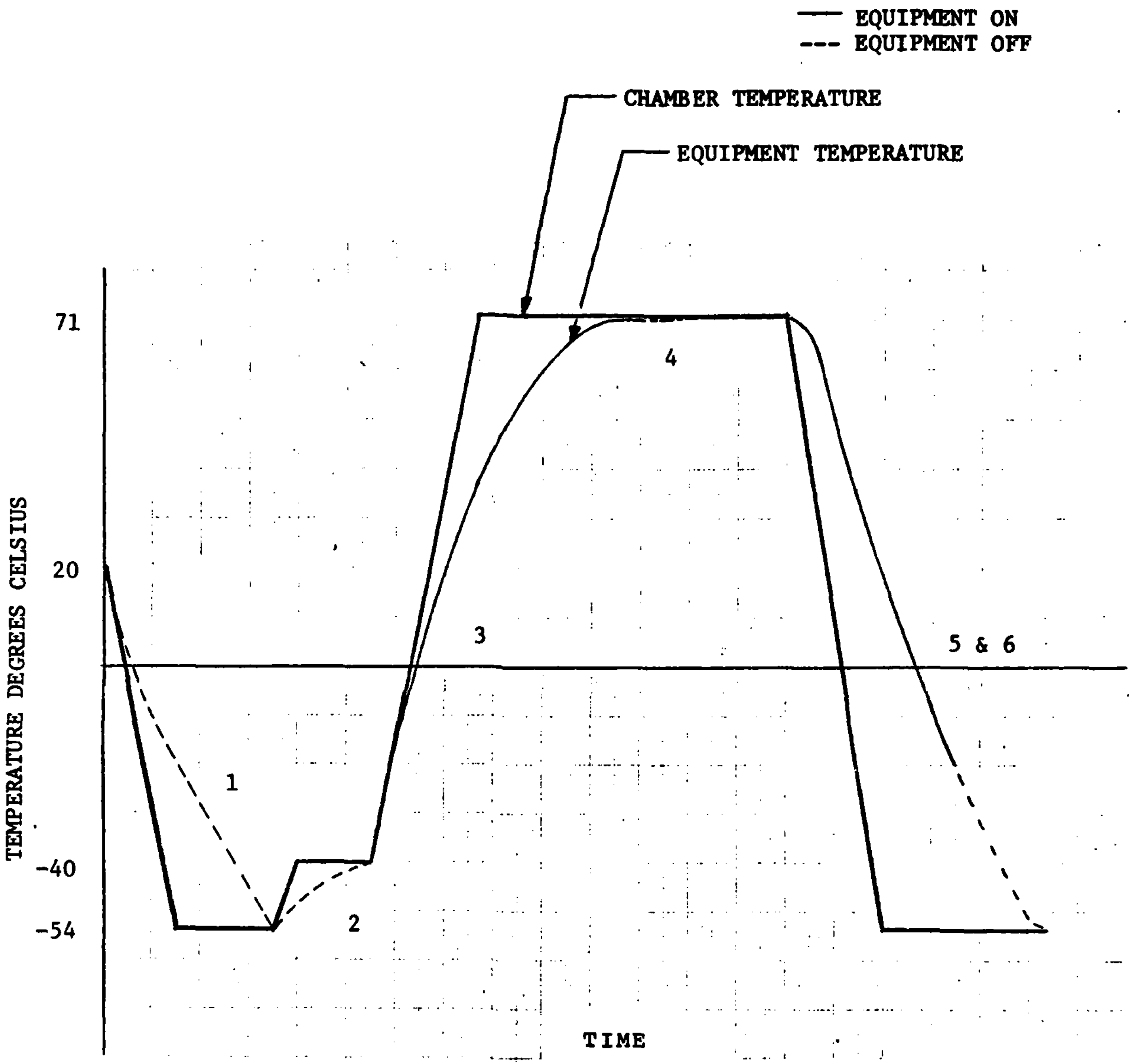


FIGURE 9 - SINGLE PVT TEMPERATURE CYCLE

herein to expose design deficiencies and defects due to inadequate quality control, introduction of new production lines or design changes. Each deliverable INU shall be subjected to the PVT sequence. All normal INU outputs shall be monitored for compliance with the requirements of this specification during each portion of the PVT cycle when the INU is operating.

4.2.6.1 Procedure. The test procedure consists of the following sequence of events:

a. Random Vibration - see paragraph 4.2.6.1.1
b. Temperature Cycling - see paragraph 4.2.6.1.2
c. Acceptance Test - see paragraph 4.2.3

Figure 7 illustrates the PVT test sequence. For each test condition specified in the PVT, the INU while operating, shall be provided with cooling air equivalent to that as specified in paragraph 3.3.4 herein.

4.2.6.1.1 Random Vibration. As illustrated in Figure 7, the INU shall be subjected to random vibration at a minimum power spectral density (PSD) of $0.04g^2$/Hz, for 10 minutes in each of the three orthogonal axes illustrated in Figure 8. The INU shall be operating while being subjected to this test.

4.2.6.1.2 Temperature Cycling. Each PVT sequence shall include a minimum of 15 consecutive failure free temperature cycles. Temperature cycles shall be as illustrated in Figure 9 and as described in paragraph 4.2.6.1.2.1. A thermal survey shall be run in accordance with MIL-STD-781C, paragraph 5.1.5, to establish the INU stabilization temperature.

4.2.6.1.2.1 Temperature Cycle Steps. Each PVT sequence shall consist of the following steps as illustrated in Figure 9.

STEP	DESCRIPTION
1	Reduce the chamber air temperature at a minimum rate of 5°C/minute and stabilize INU temperature at -54°C.
2	Raise the chamber air temperature at a minimum rate of 5°C/minute and stabilize INU temperature at -40°C.
3	Turn the INU on and perform a gyrocompass alignment while raising the chamber air temperature at a minimum rate of 5°C/minute but not to exceed 102°C/minute from -40°C to +71°C. Switch to the "NAV" mode as soon as the INU transmits a "NAV READY" status or after 12 minutes of alignment, whichever occurs first. Monitor INU performance with position observations taken at least every ten minutes. Minimum time in "NAV" mode shall be 90 minutes.

4 Upon completion of the first 90 minute navigation run, turn the INU off. Wait five minutes, turn the INU on and perform a gyrocompass alignment. As soon as the INU stabilizes at +71°C, without respect to the above turn-off or five minute waiting period, reduce the chamber air temperature at a minimum rate of 5°C/minute but not to exceed 102°C/minute to -54°C. Switch to the "NAV" mode as soon as the INU transmits a "NAV READY" status or after eight minutes of alignment, whichever occurs first. Monitor INU performance with position observations taken at least every ten minutes. Minimum time in "NAV" mode shall be 90 minutes.

5 Turn the INU off. Continue temperature cycling by stabilizing the INU temperature at -54°C. Repeat steps 2 thru 4 until 15 consecutive failure free cycles have been completed.

6 At the end of the second navigation run of failure free cycle number 15, turn the INU off and return the chamber temperature to ambient.

4.2.6.2 Failure and Retest Criteria. A failure for PVT is defined as the inability of the INU to perform its prescribed function within specified tolerances.

4.2.6.2.1 Failure Necessitating INU Retest During PVT.

a. There shall be no adjust, replacement, or repair of a part or assembly within the INU during the failure free period (see Figure 7).

b. The need to reprogram the INU shall be classified as a failure.

c. Failures which are directly attributed to technician error made during test or test equipment malfunction, which do not require replacement or repair of a part or assembly may not require a repeat of completed PVT cycles. The government shall determine if completed cycles shall be repeated.

d. Navigation accuracy errors greater than the following shall require a restart of the PVT:

(1) 1.0 NM/HR CEP for the 30 navigation runs in the 15 cycle PVT. (See Note 6.2 for the method of calculating circular error probable.)

(2) Any error within a single navigation run exceeding an envelope bounded by 0.9 NM position error during the first 21.6 minutes and 2.5 NM/HR position error rate for the remainder of the navigation run. All position error rates shall be referenced to the time that the "navigate" mode is entered.

4.2.6.2.2 Retest Criteria. Any system which fails while attempting to satisfy the PVT failure free requirements including final acceptance testing shall be required to restart the PVT procedure except as specified in paragraph 4.2.6.2.1.

4.2.6.2.3 PVT Trial Cycles. Any system which fails during PVT cycling or acceptance testing may, at the option of the test supervisor, be submitted to PVT or burn-in type trial cycles for troubleshooting or to verify the validity of any repairs performed. Failures occurring during these trial cycles shall be recorded by the contractor, but shall not be included in the customer failure reporting documents. Prior to start of the trial cycle, the log shall identify the cycle and associated data as "Trial Cycle".

4.2.6.3 Failure Reporting and Analysis. All failures occurring after the system has started the PVT shall be reported and analyzed. A summary of all failures shall be provided to the government as required in the contract.

4.2.6.3.1 Test Log Book. All failures during the Production Verification Test sequence, after completion of the contractor burn-in, shall be recorded. A test log book shall be maintained for each INS and shall accompany it throughout the test period. Each page of the log shall be signed or stamped by the government representative.

4.2.7 Maintainability/BIT Demonstration.

4.2.7.1 General. Compliance with the requirements of this specification for maintainability/BIT will be demonstrated through the testing outlined below. The testing to determine compliance will be integrated with other quality assurance tests as applicable.

4.2.7.2 Maintainability Demonstration. Compliance with the requirements of paragraph 3.2.4.2 (excluding ERT and Mmax requirements) shall be assessed by inspection (observation) during the maintainability demonstrations delineated in paragraphs 4.2.7.2.1 and 4.2.7.2.2.

4.2.7.2.1 Organizational Level. A demonstration of organizational level maintainability requirements (excluding LRU fault location) shall be accomplished and shall simulate as closely as practical the organizational scenario. The demonstration shall include the following organizational level maintenance tasks:

1. Removal and replacement (not including vehicle access time).

2. Checkout of repair.

The above maintenance tasks shall be performed 10 times. Where practical, two or more LRUs shall be used during the demonstration in order to assess the interchangeability of the equipment. The Organizational Level Equipment Repair Time (ERT) acceptance criterion, based on the sample size of 10, shall be in accordance with MIL-STD-471A (Test Method 4) and is shown below:

1. $$\log MTTR_G - \log ERT \leq \frac{1.833\ (S)}{\sqrt{9}}$$

$$\log MTTR_G - \log ERT \leq 0.611\ (S)$$

2. Mmax $\leq$ 30 minutes

4.2.7.2.2 Intermediate Level. A demonstration to show compliance with the intermediate level maintainability requirements and to systematically gather BIT information as identified in paragraphs 4.2.7.3 and 4.2.7.4 shall be performed. This demonstration shall be accomplished in accordance with MIL-STD-471A using Test Method 4 except that the sample size required is 40 and the acceptance criterion for the Intermediate Level ERT requirements is obtained as shown below:

1. $\log MTTR_G - \log ERT \leq \dfrac{1.68\ (S)}{\sqrt{39}}$

   $\log MTTR_G - \log ERT \leq 0.269\ (S)$

2. $M_{max} \leq 1.5$ hours

For the purpose of this demonstration the "Functional Level of Maintenance" shall be at the SRU level and the "Maintenance Task(s)" shall not extend below the SRU level (See MIL-STD-471A, Table I, page 24). The circuit element (piece part) to the "failed" shall be randomly selected based on the relative frequency of circuit element malfunctions within the selected SRU (Note: The SRU (maintenance task) is randomly selected in accordance with MIL-STD-471A).

4.2.7.3 Failure Detection. Data to determine degree of compliance with the requirements of paragraph 3.2.4.3.1 shall be obtained from two sources, i.e.:

a. By recording INS BIT capability to indicate or fail to indicate the existence of an INS malfunction when sample failures are introduced as required in paragraph 4.2.7.2.2 above.

b. By recording (1) BIT capability to indicate, or fail to indicate INS malfunctions and (2) false failure indications occurring during the combined environments test (paragraph 4.2.5) and all other system tests required in this specification.

4.2.7.4 Failure Location. The contractor shall maintain a record of all failures occurring or introduced into the INS during the maintainability demonstration, combined environment tests, and all other system tests required in this technical exhibit. At each failure event or malfunction, the BIT capability to locate the source of the failure to the fault LRU and the SRU will be recorded. In the event the BIT circuitry fails, or is unable to detect or locate an equipment failure, an analysis shall be made and documented. From these data, equipment compliance with the requirements of paragraph 3.2.4.3.2 will be determined.

5.0 PREPARATION FOR DELIVERY

5.1 General. The INS shall be packaged, packed and marked for delivery in accordance with the applicable purchase order. Packing shall be adequate for the type and conditions of shipment.

6.0 NOTES

6.1 Position Accuracy. We are defining CEP to be a best fit number half under and half over the as-specified performance data. The best fit line must be forced through the zero intercept at time zero. Furthermore, the CEP line should be a straight line. The civil requirement is imposed to comply with FAA certification rules and is the governing requirement for flights longer than one hour. The military navigation accuracy requirement will be the governing requirement for flight durations up to one hour. Position accuracy will be based on an ensemble of flights. 0.8 NM/HR (1.48 KM/HR) CEP converts to 1.7 NM/HR (3.1 KM/HR) on a 95 percentile basis.

6.2 PVT Navigation Accuracy. CEP will be calculated as the Root Mean Square (RMS) of the total ensemble of radial position error rates (RPER) times a 0.83 factor with N defined as the total number of observations.

$$\text{CEP} = 0.83\sqrt{\frac{\Sigma(\text{RPER})^2}{N}}$$

For example, a 15 cycle temperature cycling test consisting of thirty-90 minute navigation runs with observations taken every ten minutes would have N equal to 270.

6.3 Velocity Accuracy. The intent of specifying an RMS number here was to warrant that 68 percent of the data taken would fall within the specified limit. Further, the RMS is taken over an ensemble of time so that the maximum RMS number is always met within the first two hour period. For purposes of analysis, a perfect barometric input of zero will be assumed here. The following equation may be used for making time RMS calculations.

$$\text{RMS Velocity} = \left[\frac{1}{M}\sum_{K=1}^{M}\left[\frac{1}{N}\sum_{i=1}^{N} V_K^2(t_i)\right]\right]^{1/2}$$

where t_i is equally spaced across time and K is the index across the ensemble of runs. N is total number of data points per run and M is the total number of data runs.

6.4 Coordinate Frame Definitions. Coordinate frame definitions and sign conventions are unruly devices which have the irritating characteristics of being inconsistent and difficult to remember. Unfortunately, the coordinate frame definitions for the Standard INS are no different. However, there is a rationale behind the definitions which, though a little torturous, hopefully will provide some help in separating the positives from the negatives. It begins with the goals that the coordinate frames be right-handed and that the X-axis of all frames be co-linear when all

angles are zero (latitude, longitude, roll, pitch, heading, and stabilized platform angles). Secondly, it was decided that an easy to remember relationship between vehicle rates and platform coordinates would be helpful. With positive vehicle rates defined as those resulting in a climbing, right-hand turn (roll: right wing down; pitch: nose up; yaw: right turn), it was concluded that it would be reasonable, under the zero initial angle conditions, to have the platform axis coincident with the positive vehicle rate vectors (taken one at a time) as defined by the right-hand rule. The result (with all angles zero) placed the platform X-axis north, platform Y-axis west, and Z-axis up.

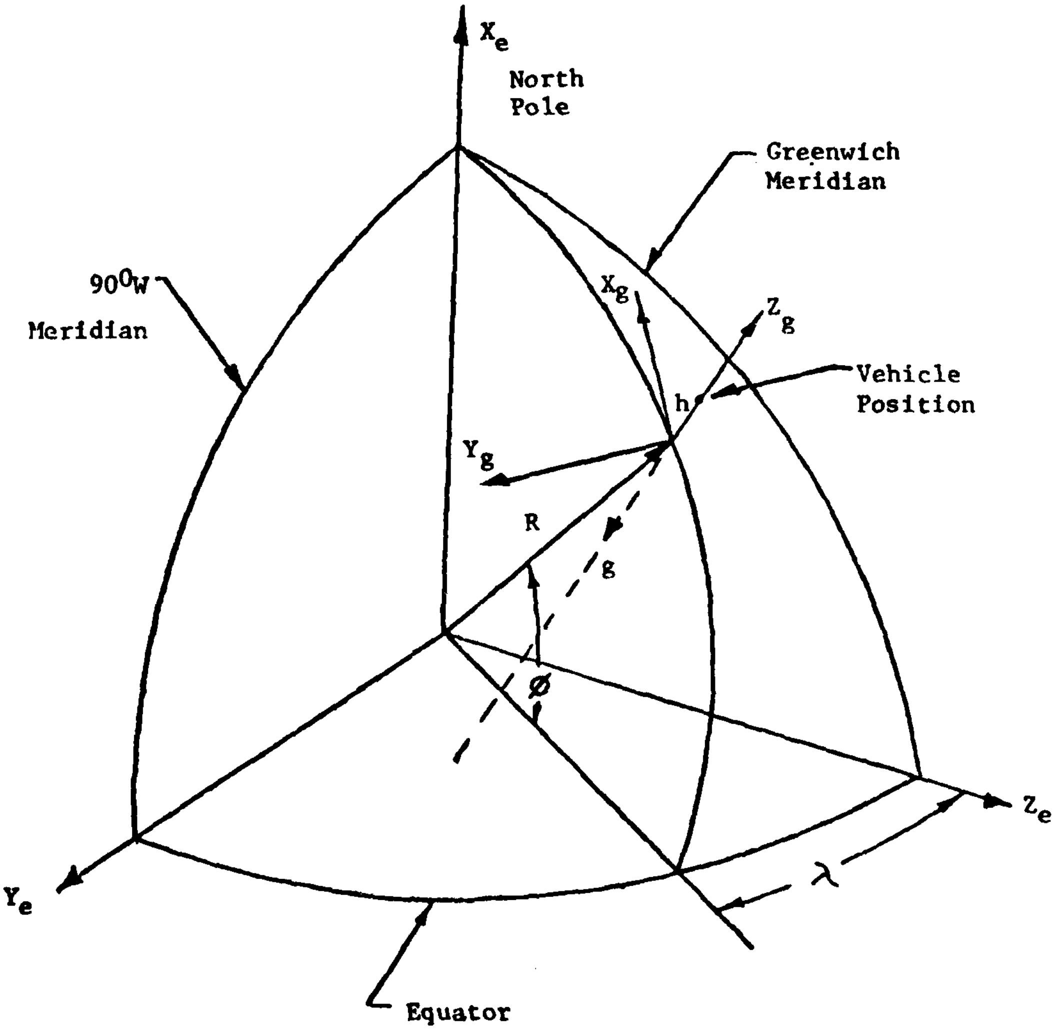
6.5 Platform Coordinates. The "platform" coordinates represent the frame of reference for defining the acceleration, velocity and attitude requirements for the Standard INS. It is defined by an orthogonal triad of axis X_p, Y_p, Z_p, which are the representation of the geodetic axis (X_g, Y_g, Z_g) embodied in the mechanized inertial sensor assembly.

6.6 Earth-Centered System. The earth-centered, fixed system is defined by an orthogonal triad of axis Xe, Ye, Ze with origin at the mass center of the earth. Xe is directed north along the polar axis. Ye and Ze are in the equatorial plane with Ze directed through the Greenwich meridian, and Ye directed through 90° W longitude. Geographic position denoted in terms of geodetic latitude (ϕ), longitude (λ) , and altitude (h), is defined with respect to the earth-centered fixed system as shown in Figure A.

6.7 Local Geodetic System. The local geodetic system is defined by a right-handed orthogonal triad of axis Xg, Yg, Zg with directions determined by horizontal north, horizontal west, and a negative gravity vector respectively at the true geographic position of the Standard INS (See Figure A).

6.8 "Platform Coordinates". This system of axis is introduced as a common medium for representing performance parameters in a physical reference frame mechanized within the vehicle which can be directly related to the vehicle axis (unlike earthbound geodetic coordinates). The use of the term platform is not to be construed as specifying or favoring a mechanization, but merely in defining a reference frame in which certain errors must be described.

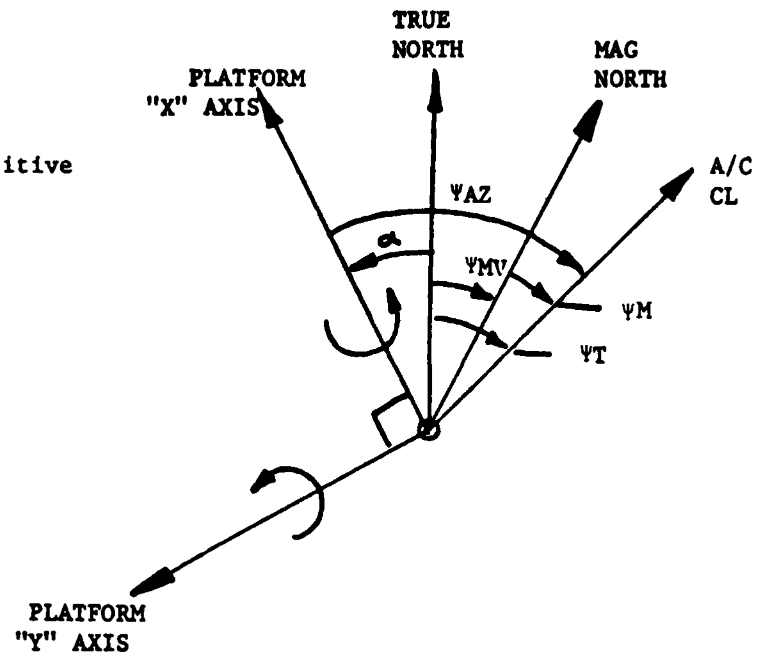
In an ideal system, Xp, Yp and Zp will coincide with Xg, Yg, and Zg. If an orthogonal set of inertial sensing instruments is mechanized, then Xp, Yp and Zp will be related to the nominal inertial sensor input axis set by an orthogonal transformation (non-orthogonalities between such instrument input axis will, of course, lead to errors both in the nominal instrument axis and



Ø - Latitude
λ - Longitude
h - Altitude
R - Earth Radius

FIGURE A - EARTH CENTERED, EARTH FIXED COORDINATE SYSTEM

ψT = True Heading
ψMV = Magnetic Variation
ψM = Magnetic Heading
"Z" platform axis is positive when directed up.
Latitude is positive in Northern Hemisphere



θSC = Selected Magnetic Course
ψG = True Ground Track
ψB = Steerpoint True Bearing
θRB = Steerpoint Relative Bearing
θCD = Course Deviation, positive when steering bar is to the right - a steer to the right is commanded.

θ_{SE} = Great Circle Steering Error

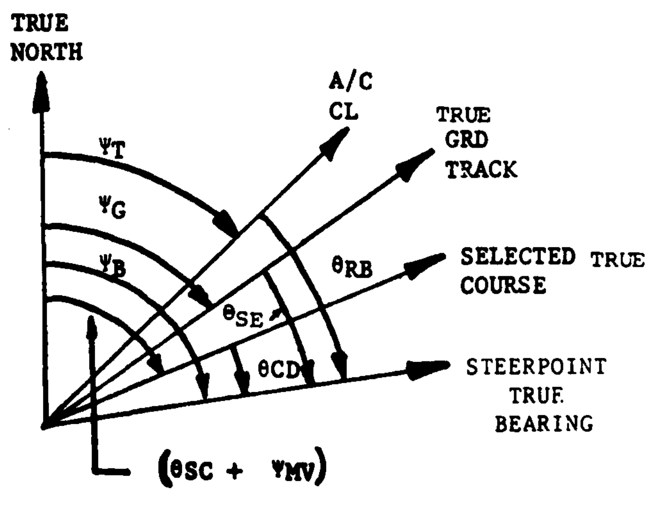


FIGURE B

DEFINITION OF INS AZIMUTH ANGLES

in Xp, Yp and Zp coordinates). (When velocity or acceleration errors are required to be evaluated in vehicle coordinates, they will be obtained, in part, from transformation of corresponding errors appearing in the stabilized platform through the vehicle attitude angles.) To obtain the total errors in vehicle coordinates, it would, of course, be necessary to add the effects of the vehicle-to-INU boresight errors.

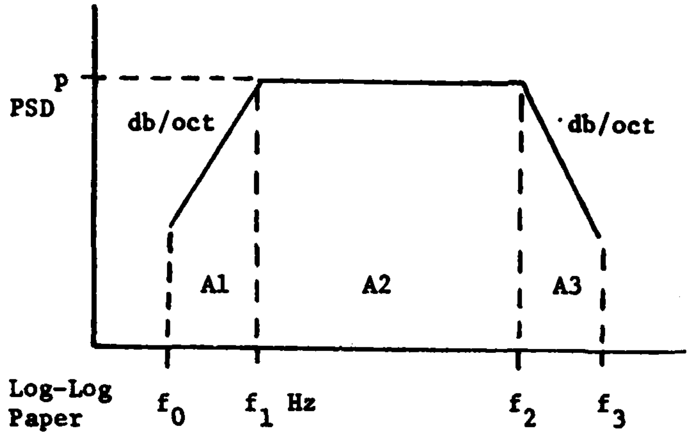
6.9 Latitude Range/Vehicle Motion During Alignment. Air vehicle motion during alignment will be characterized by 0.05g at 1.0 H_Z lateral displacement, plus a 2 cm movement in 0.5 seconds at the least opportune moment during alignment. This specification was produced after a study of a number of aircraft (RAE Technical Report TR 67132) which indicated that most air vehicle undercarriage suspensions appear to be tuned to 1 Hz and have the virtue of being readily simulated in the laboratory, even if it does not exactly represent true conditions.

6.10 Align Time. This INS function is to clue the maintenance man on when the system was switched from align to navigate to preclude having a system being pulled and later retesting OK because the operator switched to NAV mode before gyrocompass alignment was completed. The align time status and time at which system was switched to NAV will be stored in the computer memory such that only the maintenance officer can erase it from memory. In addition, the INU should have the capability to count and store the number of times the unit is cycled ON and OFF. This data will be used to make an operational reliability assessment.

6.11 Cooling Air Conditions. The minimum and maximum abnormal supply air temperatures are transient in nature. The normal supply temperatures occur when the vehicle ECS is functioning properly. The abnormal supply temperatures occur when ram air is supplied to the INS because of a failure in the vehicle ECS, and during initial cool-down or heat-up.

6.11 Vibration

Method for calculating overall Grms levels for random vibration spectrums.



A = Area Under Each Exponential Curve
P = PSD Level in Flat Region (G^2/Hz)
R = Rolloff Rate (Db/oct)

LET: $Z_1 = \frac{R}{3} + 1$, with respect to A_1

$Z_3 = \frac{R}{3} - 1$, with respect to A_3

THEN: $$A_1 = \frac{Pf_1}{Z_1}\left[1 - \left(\frac{f_0}{f_1}\right)^{Z_1}\right]$$

$$A_2 = P\,(f_2 - f_1)$$

$$A_3 = \frac{Pf_2}{Z_3}\left[1 - \frac{1}{\left(\frac{f_3}{f_2}\right)^{Z_3}}\right]$$

Caution, when R = 3, $A_3 = 2.3\ Pf_2 \text{ Log } f_3/f_2$

Reference: Tustin Institute of Technology, Revised 1972

APPENDIX I

INU INPUT SIGNAL INTERFACES

INPUTS

SIGNAL	REMARKS	UNITS	RANGE REQD	POSITIVE DIRECTION
True Air Speed	Serial Digital	Knots	0-999	
Baro Altitude		Feet	0-99999	
Cal Mode		-	-	
Test Mode		-	-	
Heads Up Display		Degrees	0-359.9	CW WRT True North
Sensor (TACAN, Doppler GPS, etc.)		See Appropriate F02 Message Block		
Selected Course		Degrees	0-359.9	CW WRT True North
UTM Coordinates:				
Spheroid	USASC II	-	-	
Grid Zone Designation		2 Numeric 1 Alpha	0-60 A-z	
100,000 Meter Square		2 Alpha	A-Z	
Easting	Binary	Meters	0-9999	
Northing	Binary	Meters	0-9999	

Note: Refresh and Transmission rates are contained in Table VI-2 and data word formats of Table VI-8.

INPUTS (Cont'd)

SIGNAL	REMARKS	UNITS	RANGE REQD	POSITIVE DIRECTION
C_{XX}	Serial Digital	None	± 1	-
C_{XY}				-
C_{XZ}				-
Longitude		Semicircle		East
Velocity Cor. X		Ft/Sec	± 2500	+X
Velocity Cor. Y		Ft/Sec	± 2500	+Y
Tilt Cor. X		Arc Sec	$\pm 2^{15}$	R.H. WRT +X
Tilt Cor. Y		Arc Sec	$\pm 2^{15}$	R.H. WRT +Y
Gyro Bias Cor. X		Rad/Sec	$\pm 2^{-13}$	R.H. WRT +X
Gyro Bias Cor. Y		Rad/Sec	$\pm 2^{-13}$	R.H. WRT +Y
Gyro Bias Cor. Z		Rad/Sec	$\pm 2^{-13}$	R.H. WRT +Z
Steering Error		Semicircle	± 1	Right Steering Command
CADC Mode Word		-	-	-
Pressure Alt.	Serial Digital	Feet	-1500 to +80,000	
Convergence Factor	Serial Digital	-	0 - 1.00000	-

Note: Refresh and Transmission rates are contained in Table VI-2 and data word formats of Table VI-8.

INPUTS (Cont'd)

SIGNAL	REMARKS	UNITS	RANGE REQD	POSITIVE DIRECTION
Mode Word CAC/INU/CDU	Serial Digital	-	-	-
Panel Switch Words 1 & 2		-	-	-
Keyboard Functions:				
POS & DEST Latitude	(BCD)	Deg. & Min.	±90	North
POS & DEST Longitude	(BCD)	Deg. & Min.	±180	East
POS True Heading	(BCD)	Deg.	0-359.9	CW WRT True North
STD Mag Hdg	(BCD)	Deg.	0-359.9	CW WRT Mag North
POS Mag. Variation	(BCD)	Deg.	±179.9	CW WRT True North
MISC Mem. Address	(BCD)	-	-	-
Alpha Display Char. (3)		-	-	-
CDU/INU Mode Word		-	-	-
***CAC/INU Mode Word**		-	-	-
Strg Points 0-9 Coord				
Latitude		Semicircle	±1	North
Longitude				East
Mark Points 1-3 Coord:				
Latitude				North
Longitude				East

*CAC- Central Airborne Computer

NOTE: Refresh and Transmission rates contained in Table VI-2 and data word formats of Table VI-8.

APPENDIX II

INU OUTPUT SIGNAL INTERFACES

OUTPUTS

SIGNAL	REMARKS	UNITS	RANGE REQD	POSITIVE DIRECTION
IMU Mode Word	Serial Digital	-	-	-
Time Tag		64 usec (LSB)	-	-
Velocity X		Ft/Sec	± 2500	+X
Velocity Y				+Y
Velocity Z				+Z
Platform Azimuth		Semicircle	± 1	CW WRT X Axis
Roll				Right Bank
Pitch				Nose Up
True Heading				CW WRT True North
Magnetic Heading				CW WRT Mag. North
Acceleration X		Ft/Sec^2	± 512	+X
Acceleration Y				+Y
Acceleration Z				+Z
C_{XX}		None	± 1	-
C_{XY}				-
C_{XZ}				-
Position Error N/S		NM	0-999.9	North
Position Error E/W			0-999.9	East

Note: Refresh and Transmission rates are contained in Table VI-2 and data word formats of Table VI-8.

OUTPUTS (Cont'd)

SIGNAL	REMARKS	UNITS	RANGE REQD	POSITIVE DIRECTION
Longitude	Serial Digital	Semicircle	± 1	East
Latitude		Semicircle	± 1	North
Inertial Alt.		Feet	-1060 to +80,337.5	+Z
Computed Course Deviation		Semicircle	± 1	CW WRT Grd Track
Residual Tilt X		Arc Sec	± 429.406	R.H. WRT +X
Residual Tilt Y		Arc Sec	± 429.406	R.H. WRT +Y
BITE Summary Words (2)		-	-	-
Alpha Display Char. (3)		-	-	-
L. Misc. Display	(BCD)			
R. Misc. Display	(BCD)			
Backup INU/CDU Mode Word		-	-	-
Backup Alpha Display Char. (3)				
Fault Ack.				
Backup L. Misc. Display				

*At latitudes above 80° , refresh rate is 5/Sec.

Note: Refresh and Transmission rates are contained in Table VI-2 and data word formats of Table VI-8.

OUTPUTS (Cont'd)

SIGNAL	REMARKS	UNITS	RANGE REQD	POSITIVE DIRECTION
Great Circle Steering Error	Serial Digital	Semicircle	± 1	CW WRT True Track
Relative Bearing				CW WRT True Heading
Selected Magnetic Course				CW WRT Mag Heading
Mag Heading* to selected Waypoint/Markpoint				CW WRT Mag Heading
True Air Speed*		Knots	0-999	-
Magnetic Ground Track		Semicircle	± 1	CW WRT Mag Heading
Magnetic Variation		Degrees	± 179.9	CW WRT True North
Drift Angle				Right drift WRT the aircraft centerline
Present Convergence Factor in Use		-	0. - 1.00000	-
Desired Grid Heading	Serial Digital	Semicircle	± 1	CW WRT True North

Note: Refresh and Transmission rates are contained in Table VI-2 and data word formats of Table VI-8.

OUTPUTS (Cont'd)

SIGNAL	REMARKS	UNITS	RANGE REQD	POSITIVE DIRECTION
Backup R. Misc. Display	**Serial Digital**			
Align Status		**-**	**-**	
Track Angle (True)		**Deg.**	0-359.9	**CW WRT True North**
Ground Speed		**Knots**	0-2000	
Distance to Go		**NM**	0-3999.9	
Time to Go		**Min.**	0-399.9	
Wind Speed	**Serial Digital**	**Knots**	0-999	
Wind Angle		**Degree**	0-359.9	**CW WRT** True Heading
Grid Heading		**Degree**		
Cal Mode		**-**	-	-
UTM Coordinates				
Grid Zone Designation	USASC II	**2 Numeric** **1 Alpha**	0-60 A-Z	
100,000 Meter Square	**USASC II**	**2 Alpha**	A-Z	
Easting	Binary	**Meters**	0-9999	**East**
Northing	Binary	**Meters**	0-9999	**North**

Note: Refresh and Transmission rates are contained in Table VI-2 and data word formats of Table VI-8.

APPENDIX III

ANALOG/DISCRETE INPUT/OUTPUT SIGNALS

ANALOG/DISCRETE INPUTS

SIGNAL	REMARKS	UNITS	RANGE REQUIRED	POSITIVE DIRECTION
INS ON	Discrete	-	Continuity or Open pins 28 and 8, J-131	Continuity=INS ON
BUS CONTROL	Complementary Differential	-	Logic 1= +2volts min differential P131 Pin 51=+2.4v to +5.5v Pin 17=+0.0v to +0.4v	INU RT
			Logic 0= -2volts min differential P131 Pin 51 = +0.0v to +0.4v Pin 17 = +2.4v to 5.5v	INU Backup Controller
ATTITUDE MODE	Discrete	-	28 volts DC or Open	28V = True
SELECTED COURSE	3 Wire Synchro	Degrees	0 to 360	CW WRT Magnetic North
DESIGNATE	Discrete	-	28 Volts DC or Open	28V = True

ANALOG DISCRETE OUTPUTS

SIGNAL DUAL OUTPUTS **	TO (LOADS)	REMARKS	RANGE	ACCURACY	POSITIVE DIRECTION	LOAD EACH OUTPUT	PHASE SHIFT
*ROLL	ADI (2)	Synchro Buffered	0° to 360°	0.1° RMS	Right Bank	2,AY500-5 (222 +J470)Ω Zso	+14 ±4 Deg. Lead
	Autopilot (1)	↓	↓	↓	Right Bank	5KΩ Balanced	+14 ±4 Deg. Lead
*PITCH	Autopilot (1)	↓	$\pm 90^\circ$	↓	Nose Up	5KΩ ±5% Balanced	+14 ±4 Deg. Lead
	ADI (2)	↓	↓	↓	Nose Up	2, AY500-5 (222+J470)Ω Zso	+14 ±4 Deg. Lead
COMPUTED COURSE DEVIATION	HSI	Analog (DC)	$\pm 10^\circ$ (± 150 μ AMP)	± 10 μ AMP MAX	Bar to Right	1000Ω	

*The SYNCHRO output signals must interface with equipments utilizing either high or low null. Selection must be made external to the INU. The roll and pitch SYNCHRO output high null electrical zero shall be at 0° for zero roll and pitch indication when pin 25 on J-132 is open (not grounded). With pin 25 on J-132 grounded, zero roll and pitch indication shall be provided at 180° roll and pitch SYNCHRO output angles. When grounded, pin 25 shall be tied to pin 27.

**Dual outputs are from separately driven buffers.

ANALOG/DISCRETE OUTPUTS (Cont'd)

SIGNAL SINGLE OUTPUT	TO (LOADS)	REMARKS	RANGE	ACCURACY	POSITIVE DIRECTION	LOAD	PHASE SHIFT
**Computed Range to Dest.	HSI (2)	3 Synchros per HSI	0 to 999	0.5 NM RMS	Range Increase	2 Sets of 3, CRC-8-A-1 (10+J45)Ω Zso	10 ±6 Deg. Lead
**Computed Dest. Relative Bearing	HSI (2)	Synchro	0^o to 360^o	$\pm0.5^o$ MAX	CW Inc. Course	2. AY500-5 (222+J470)Ω Zso	±1 Deg.
**Mag. Heading (Platform Heading in ATT Mode)	HSI (2) TACAN	Synchro	0^o to 360^o	$\pm0.5^o$	Inc. Head WRT Mag. North	(47+J74)Ω, Min, Line-to-Line	+14 ±4 Deg. Lead
Mag. Heading Bad	Instrument Coupler	Discrete	Open or A/C +28 VDC		+28 VDC = True	720Ω ±10%	
To-From	HSI (2)	Discrete	0 ±5μ AMPS No Flag; 325 ± 100μ AMPS-TO; -325± 100μ AMPS-FROM	-	To (+)	100Ω ±15%	
Attitude Good	ADI (2)	Discrete	Open or A/C +28 volts DC	-	28 VDC = True	750Ω	
Mag. Heading Good	-	Discrete	Open or A/C +28 volts DC	-	28 VDC = True	720 Ω ± 10%	

** - Null Requirements for Outputs to HSI.

a. Computed Range to Destination Outputs. High null electrical zero shall be at 0^o for a zero range indication. Increasing synchro output angle to 36^o shall result in a "1" being displayed on the range readout on the HSI for each synchro output. Increasing numerical range readings shall be indicated for each 36^o increase in each synchro output.

b. Computed Destination Relative Bearing Output. High null electrical zero shall be at synchro output angle of 0^o. A 0^o output from the INU shall result in a 180^o position of the bearing pointer on the HSI.

c. Magnetic Heading Output. High null electrical zero shall correspond to a synchro angle of 0^o at the north heading.

AD-A084 036 AERONAUTICAL SYSTEMS DIV WRIGHT-PATTERSON AFB OH COMM--ETC F/G 17/7
CHARACTERISTIC FOR A MODERATE ACCURACY INERTIAL NAVIGATION SYST--ETC(U)
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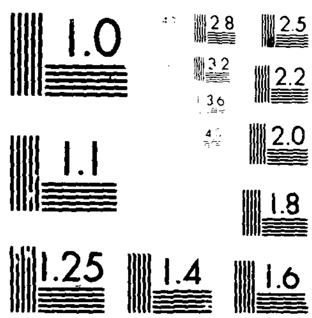
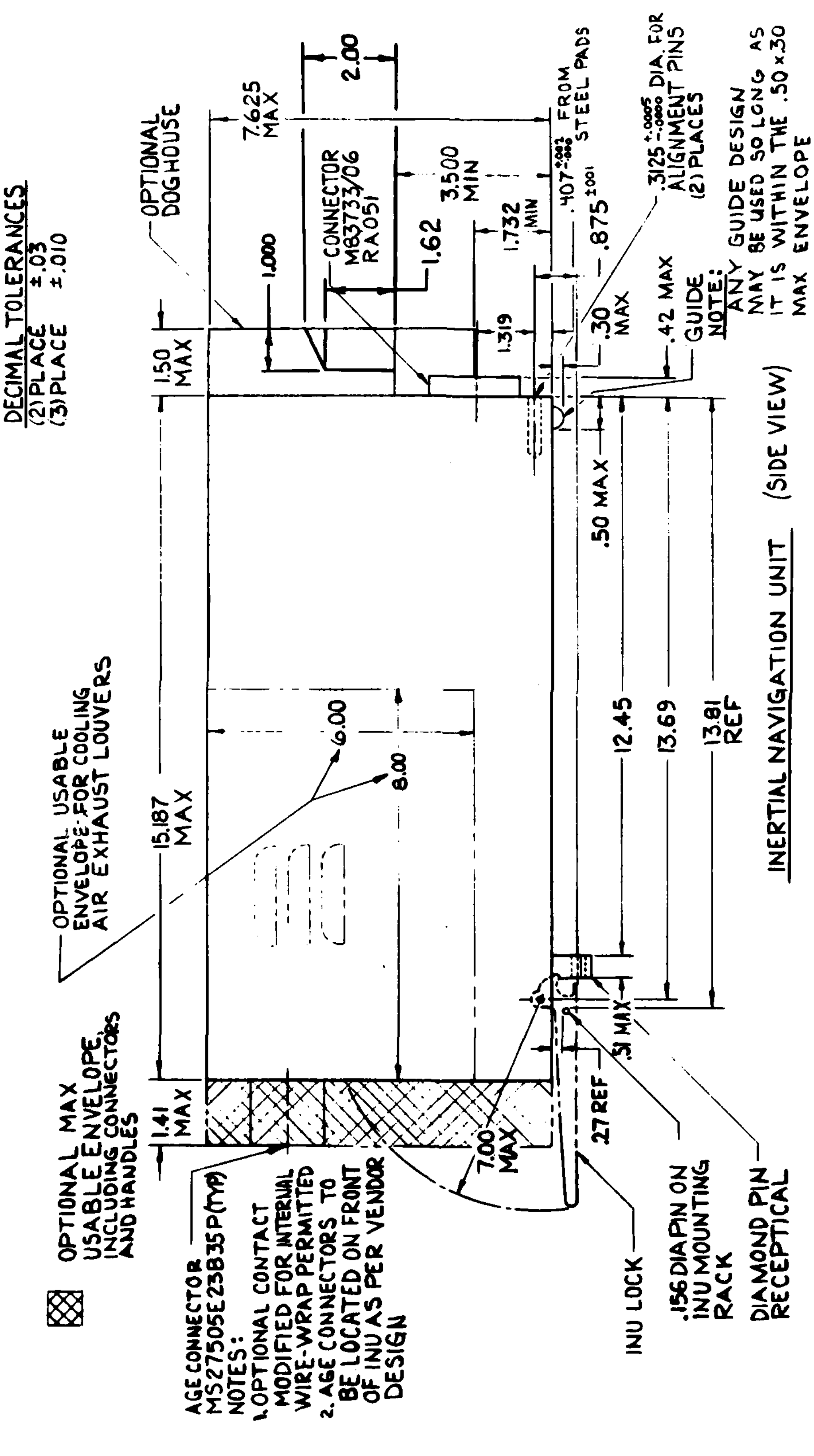


MICROCOPY RESOLUTION TEST CHART

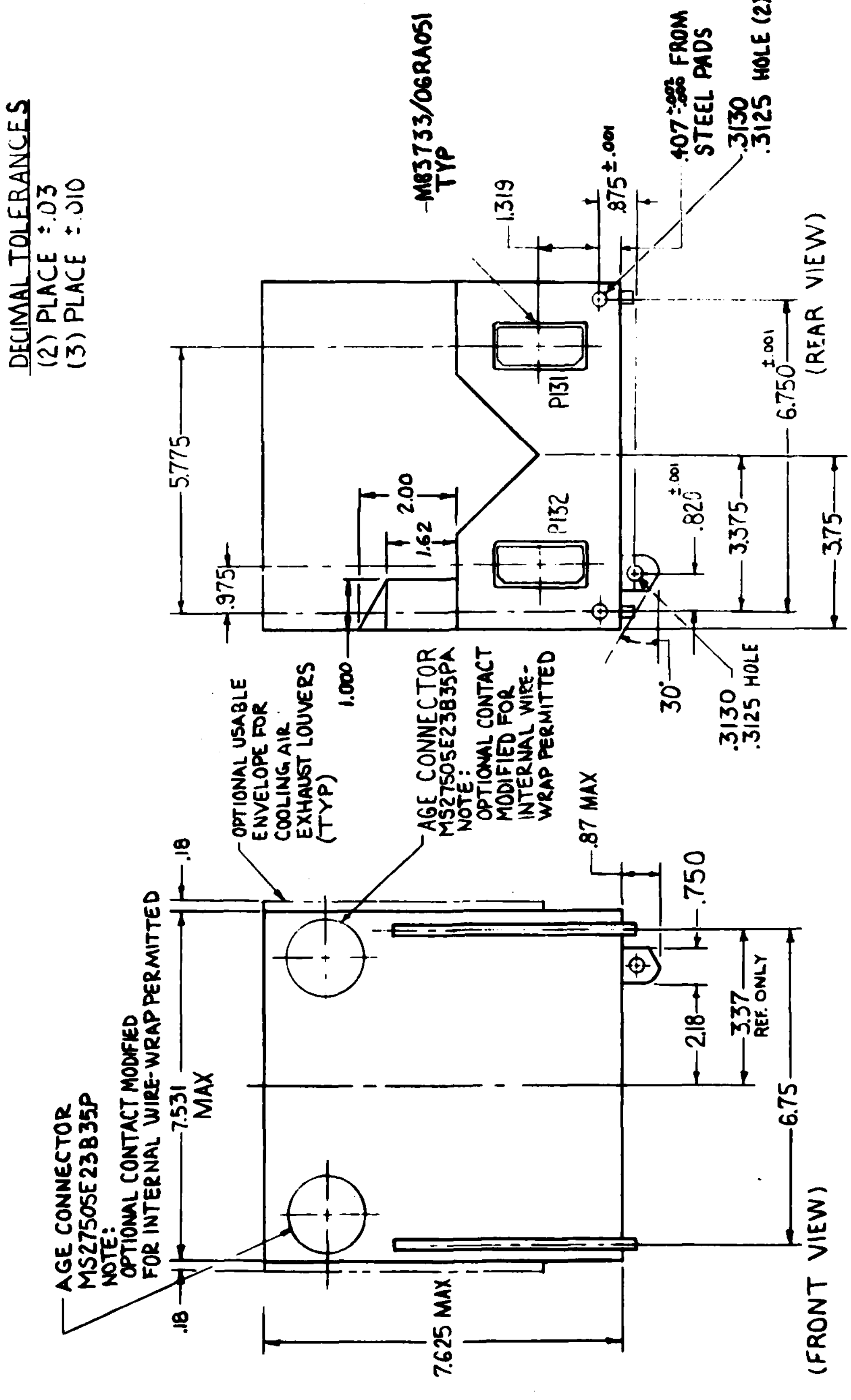
NATIONAL BUREAU OF STANDARDS 1963-A

APPENDIX IV

INS OUTLINE AND MOUNTING DRAWINGS



INERTIAL NAVIGATION UNIT (SIDE VIEW)



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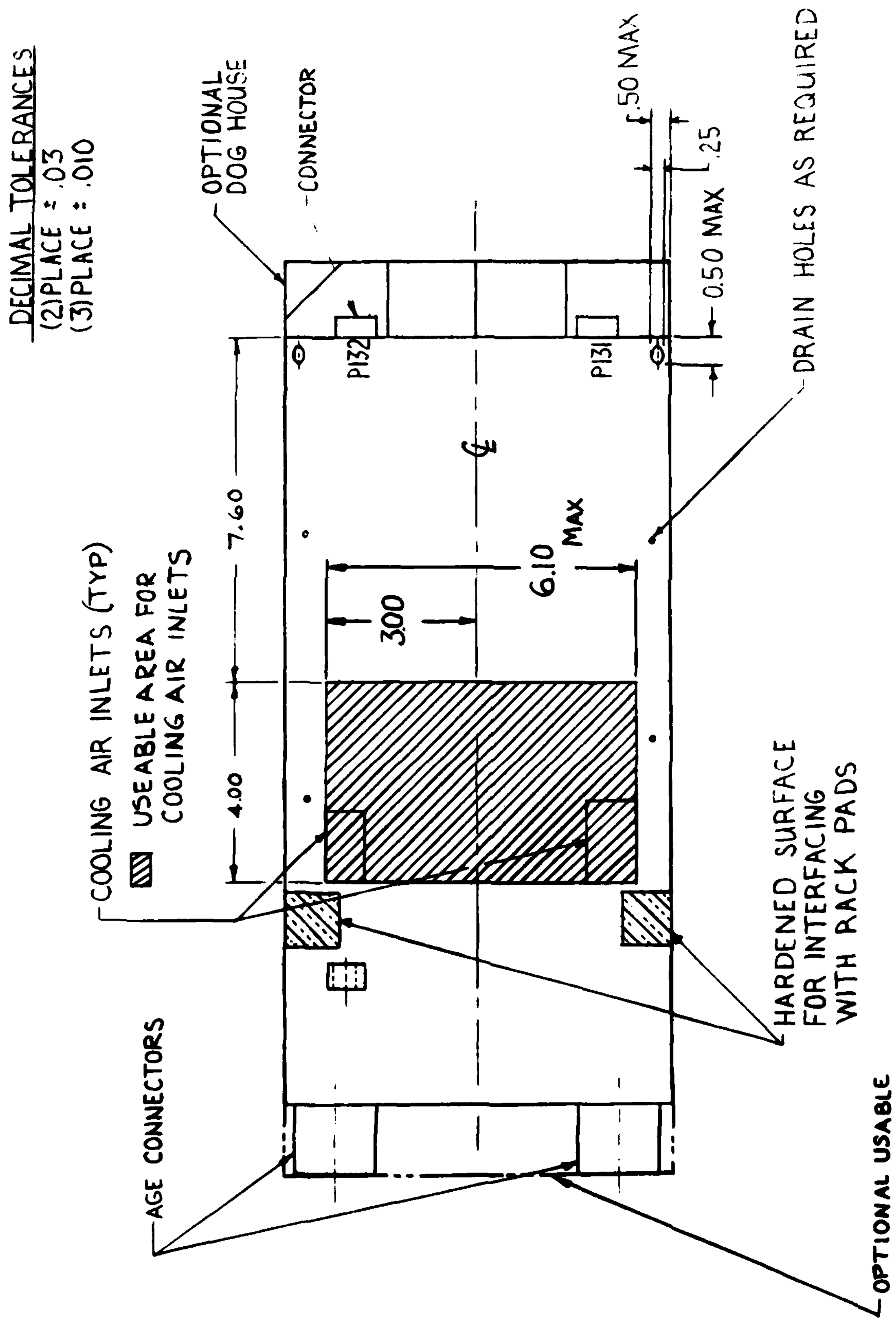
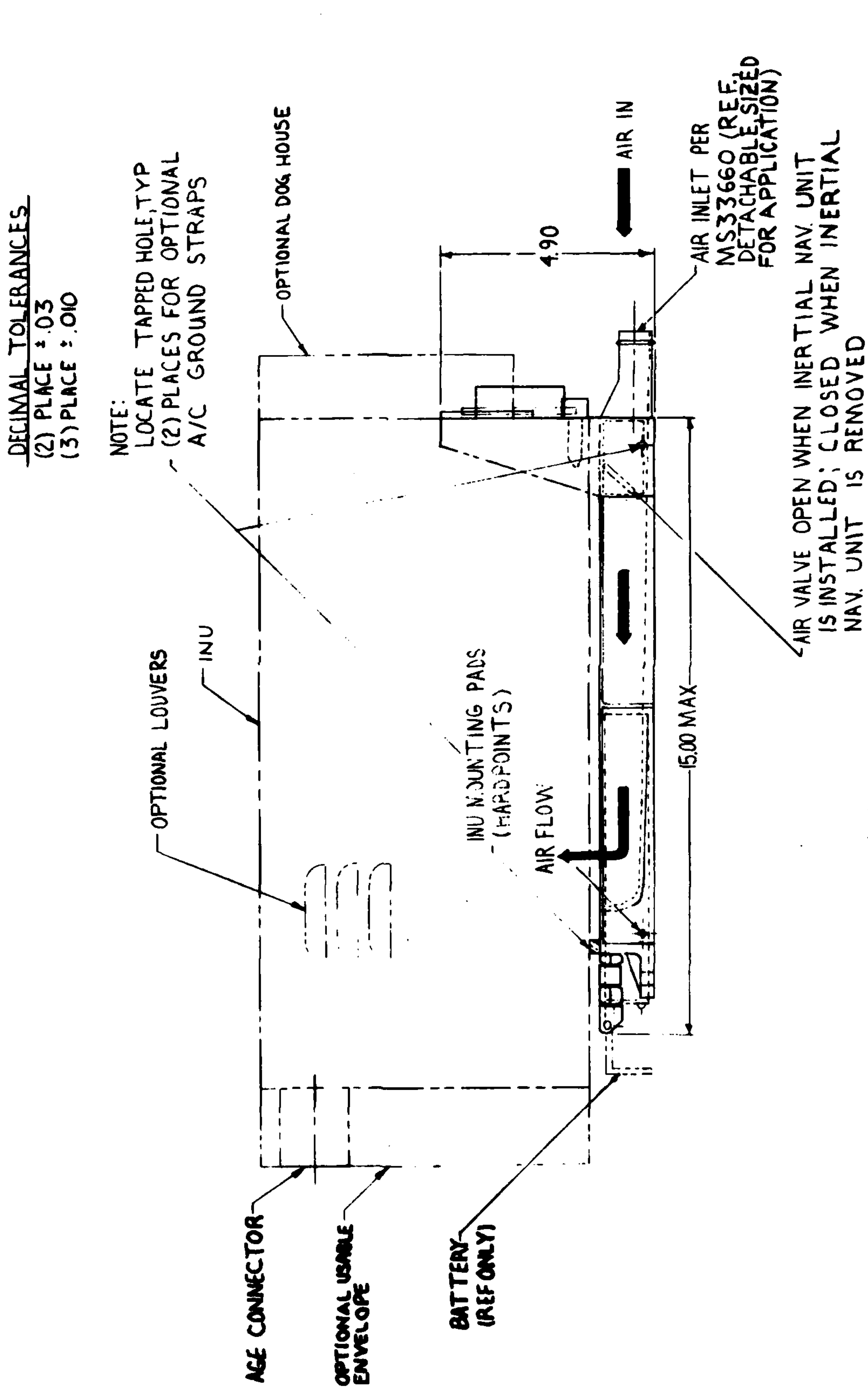
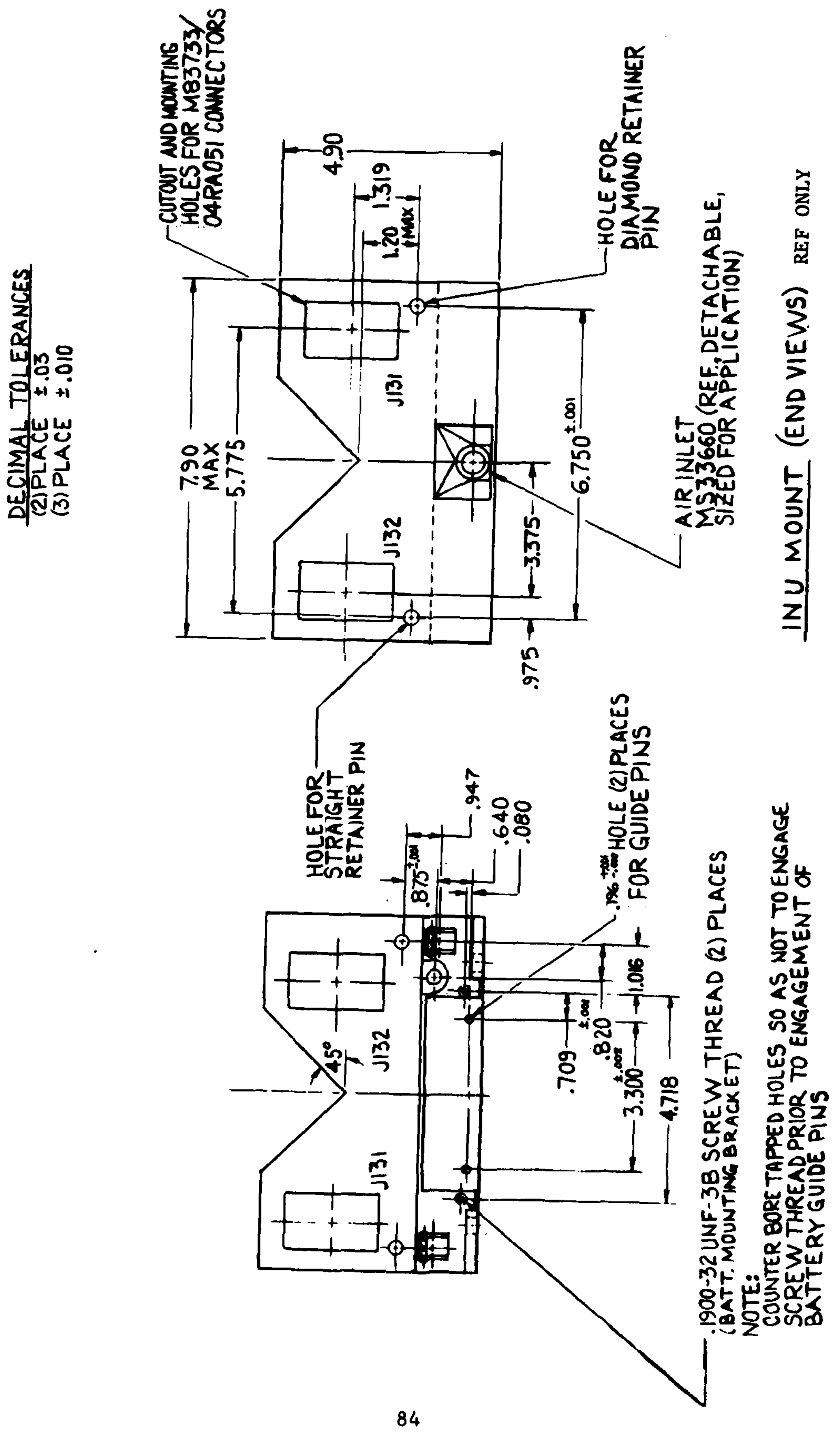


INERTIAL NAVIGATION UNIT (BOTTOM VIEW)



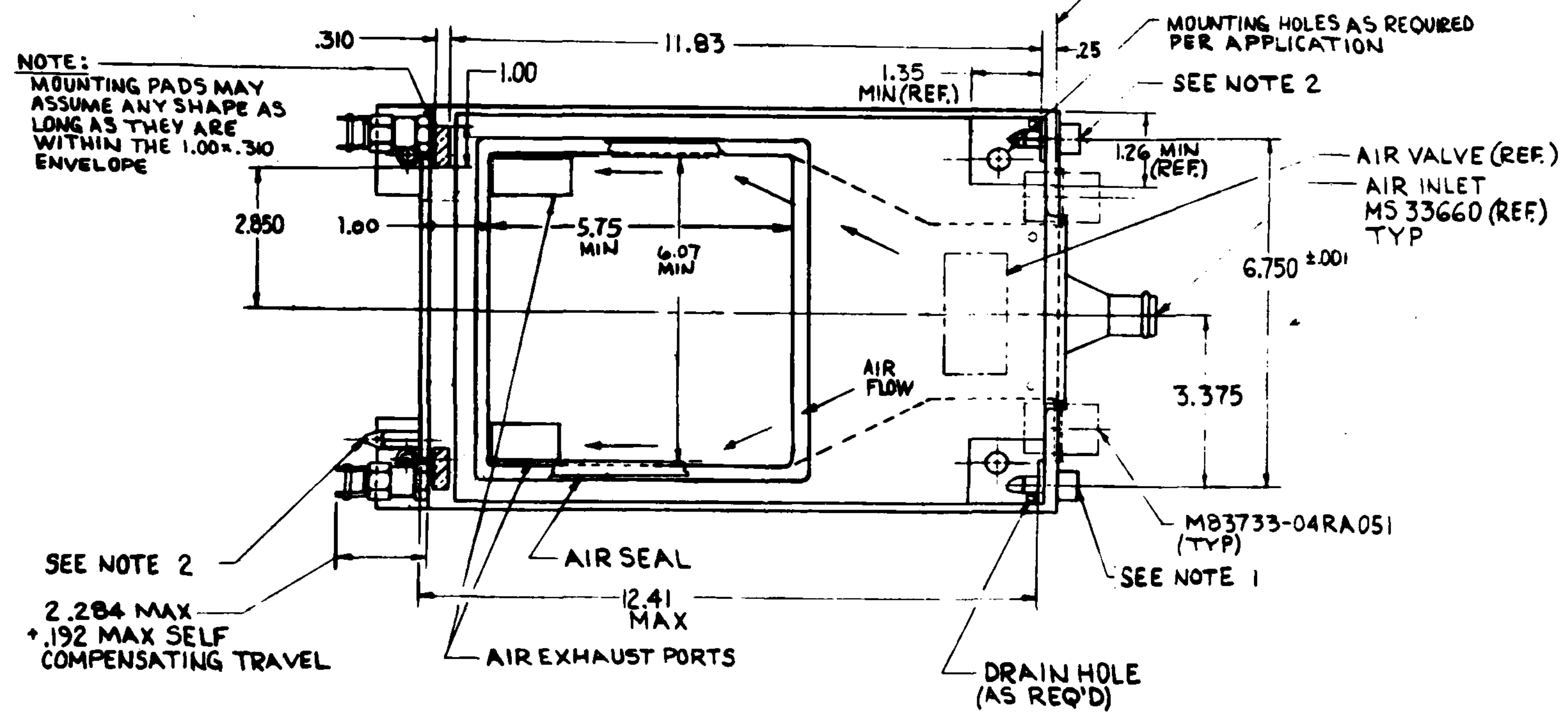
INU MOUNT
(SIDE VIEW) REF ONLY



INU MOUNT (END VIEWS) REF ONLY

NOTES:
1-ROUND RETAINER PIN .3090/.3087 O.D. (1 REQUIRED) MATES WITH .3125 [illegible] DIA.
2-DIAMOND RETAINER PIN [illegible] O.D. (2 REQUIRED) MATES WITH .3125 [illegible] DIA.

DECIMAL TOLERANCES
(2) PLACE .03
(3) PLACE .010



INU MOUNT (TOPVIEW) REF ONLY

NOTE: The INS vendor shall identify the center of gravity of his system and shall furnish that information to the procuring activity.

NOTE: In those installations where the INU is pulled from its rack toward the right wing of the vehicle , INU facing fore, the "External Control" shall be open from pin 15 to pin 16. (Pins 15 and 16 are located on connection P/J 132.) When the installation is reversed, pin 15 to pin 16 shall be jumpered, in which case the forward direction is opposite to the arrow on the Inertial Navigation Unit schematic.

NOTE: Identification of vendor box by Automated Test Equipment shall be accomplished by a resistive load being placed between pins 44 and 45 of connector P132. The following resistive loads shall identify each vendor.

Collins	OPEN
Delco	1000
General Electric	2000
Hamilton Standard	3000
Honeywell	4000
Lear Siegler	5000
Litton Guidance and Control Systems Division	6000
Litton Aeroproducts	7000
Northrop	8000
Raytheon	9000
Rockwell (Autonetics)	10000
Singer Kearfott	11000
Sperry	12000
Teledyne	13000

APPENDIX V

PERFORMANCE CERTIFICATION TEST

(LABORATORY & AIRCRAFT)

50.0 PERFORMANCE CERTIFICATION TEST

50.1 General. This appendix outlines the tests to be conducted on the INS units provided to the CIGTF in the quantity and configuration required by the contract.

50.2 Test Conditions.

50.2.1 Laboratory Standard Conditions. The following conditions shall be used to establish normal performance characteristics under standard conditions and for making laboratory bench tests:

Temperature	Room Ambient $23^{o} \pm 10^{o}C$
Altitude	Normal Ground
Vibration	Room Ambient
Humidity	Room Ambient up to 90% relative humidity

50.2.2 Input Cooling Air.

Cooling Air Temperature	Max., Min. and variations as specified in para. 3.3.4.1
Cooling Air Humidity	Up to 95% Relative Humidity
Cooling Air Flow	Per Figure 3, Cooling Air Flow Requirements

50.2.3 Input Power. The input power shall be:

AC: 113 ± 5 VAC, 400 ± 20 Hz, 3 Ø

DC: 27.5, +1.5, -2.5 VDC
240 Watts Maximum

50.3 Performance of Test.

50.3.1 Test Data. Test data shall include complete identification of the test article and all test equipment and accessories. The data shall include the actual test sequence used, ambient test conditions recorded periodically during the test, and

performance data recorded periodically during the test. Laboratory ambient data shall include as a minimum: temperature, humidity, altitude, latitude, longitude, cooling air temperature, cooling air flow rates and power. Aircraft ambient data shall include as a minimum: temperature, humidity, altitude, random vibration, cooling air temperature, cooling air flow rates and power. Performance data shall include as a minimum, indicated position and velocity components. The test record shall contain a signature and date block for certificate of the test data by the engineer.

50.3.2 Laboratory Test.

50.3.2.1 Pretest Performance. The INU shall be installed on the fixture with the case heading true north and shall be maintained in the power-off condition for a period of not less than two hours at laboratory standard conditions. Instruments will be attached as necessary. Plugs shall remain in place. When mechanical or electrical connectors are not used, the connectors normally protected in service shall be adequately covered. The test INU shall then be operated to determine that no malfunction or damage was caused due to installation or handling. This operation shall consist of aligning the system and performing static navigation.

50.3.2.2 Test Performance. When operation of the system is required during the test, the system, after alignment, shall be maintained in the navigate mode and continue to perform static navigation for the duration of the test and for a minimum of 84 minutes.

50.3.2.3 Post-Test Performance. When operation of the system is not required during the test, a post-test performance operation will be conducted. This operation shall consist of aligning the system and performing 84 minutes of static navigation.

50.4 Test Methods.

50.4.1 Laboratory Tests.

50.4.1.1 Calibration Test. The following calibration tests shall be conducted for the purpose of (1) obtaining static baseline data for reference, (2) obtaining data under special INS test conditions, and (3) to meet scheduled calibration requirements. During all calibrations, parameters being updated

and heading, pitch, and roll shall be recorded at a rate of at least once per minute (six times per minute during platform rotation). Each calibration will be concluded with an 84 minute navigation run during which position and velocity components shall be recorded at least once per minute to evaluate the quality of the calibration. Pre- and post-calibration parameters shall be tabulated. Residual gyro drifts shall be computed from the position and velocity error data. Stability of calibration parameters shall be determined between calibrations and during each calibration.

a. Baseline Test. A baseline calibration shall be conducted after initial integration of the INS and instrumentation.

b. Scheduled Maintenance Test. A calibration shall be conducted when the elapsed time since the last calibration equals or exceeds the maximum calibration intervals.

c. Moving Base Calibration Test. The purpose of this test is to evaluate the sensitivity of the INS calibration to base (mount) motions which can be quantitatively described and which reasonably simulate actual motions that can be expected at the base of the INU mount during aircraft preflight activities. Two calibration tests shall be conducted with the INS mounted on a single axis horizontal vibration table. The table will be driven sinusoidally in the North-South direction only, at one CPS, one inch peak-to-peak (equivalent to .05g zero-to-peak). At the least opportune moment (determined by analysis) during alignment, add an additional motion, a 2 cm step in .5 second.

d. Latitude Parameter Sensitivity Test. This test shall be conducted to evaluate the impact on calibration parameter values resulting from insertion of incorrect values of local latitude prior to calibration; and to determine the number of additional calibrations required, with the correct test location latitude inserted, to achieve reasonable convergence of the calibration parameter values.

The latitude parameter sensitivity test consists of the following:

(1) The calibration parameter values shall be extracted from the INS computer and recorded.

(2) The local latitude data shall be extracted and recorded. A new latitude data value (TBD by the test agency at the time of test) shall be loaded into the INS computer. The first calibration shall be conducted with the incorrect latitude.

(3) The correct local latitude data word shall be reloaded into the INS computer. Two calibrations shall be conducted to determine calibration recovery characteristics.

50.4.1.2 Gyrocompass Alignment. The following test steps shall be performed to measure gyrocompass alignment performance:

a. Alignment status, time, attitude, and calibration parameters being updated shall be recorded at least six times per minute during alignment and position, velocity and acceleration shall be recorded at least once per minute throughout the test.

b. The test shall be performed with the INU mounted on a table inside a temperature chamber.

c. Cool down for a minimum of two hours and stabilize at the prescribed temperature (See g. below).

d. The INS shall be gyrocompass aligned with a heading of 0°. Switch to the navigate mode at the prescribed time (See g. below).

e. Navigate for 84 minutes.

f. Repeat c., d., and e. for a heading of 180°.

g. Accomplish steps c. through f. for the following prescribed temperature/alignment time pairs for three runs at each heading (total of 24 runs).

TEMPERATURE	GC ALIGNMENT TIME
0°F (-17.7°C)	9 Min
-40°F (-40°C)	6 Min
-40°F (-40°C)	12 Min
+70°F (21.1°C)	8 Min

Align status, reaction time, attitude parameters, estimated alignment errors and navigation performance shall be determined for each of the above time/temperature points.

50.4.1.3 Stored Heading Alignment. The following test steps shall be performed to measure stored heading alignment performance:

a. Align status, time, attitude, and cal parameters being updated shall be recorded six times per minute during alignment and velocity, position and acceleration shall be recorded at least once per minute throughout the test.

b. The test shall be performed with the INU mounted on a table inside a temperature chamber.

c. Gyrocompass align (no cool down required) at a 0° heading. Turn system off.

d. Cool down for a minimum of two hours and stabilize at the prescribed temperature (See h. below).

e. Accomplish a stored heading alignment for the prescribed alignment time (See h. below).

f. Navigate for 84 minutes.

g. Rotate the INU by 180° and perform a gyrocompass alignment at the new heading. Turn the system off.

h. Accomplish steps d. through g. for the following temperature/alignment time pairs for three runs at each heading (total of 24 runs).

TEMPERATURE	GC ALIGNMENT TIME
0°F (-17.7°C)	2.5 Min
-40°F (-40°C)	4.0 Min
-40°F (-40°C)	2.0 Min
+70°F (21.1°C)	1.5 Min

Align status, reaction time, attitude parameters, estimated alignment errors and navigation performance shall be determined for each of the above time/temperature points.

50.4.1.4 Best Available True Heading Alignment. The purpose of the best available true heading alignment test is to verify the mechanization of the procedure. The following steps shall be performed:

a. The system shall be aligned using the prescribed gyrocompass alignment procedure.

b. The system shall be turned off for two hours and then back on without moving the INU.

c. The system shall be aligned using the prescribed best available true heading alignment procedure. The best available true heading shall be the system indicated heading at the completion of gyrocompass alignment. System indicated heading, pitch, roll and alignment status indication shall be recorded six times per minute during alignment. Position and velocity shall be recorded at least once per minute throughout the test.

d. The system shall be switched to the navigate mode for a period of not less than 84 minutes.

A time history of position and velocity shall be plotted to determine that the best available true heading alignment procedure functioned properly.

50.4.1.5 Heading Sensitivity in the Navigate Mode. The following test steps shall be performed to evaluate the INU sensitivity to heading changes after alignment.

a. The test shall be performed with the INU mounted on a movable table top. The INS shall be allowed to warmup for one hour minimum before beginning the test.

b. The INS shall be aligned using the prescribed gyrocompass alignment procedure with the INU mount aligned to north ±1 degree. Align status, roll, pitch, heading and calibration parameters being updated shall be recorded at least six times per minute during the align mode. Position and velocity shall be recorded at least once per minute throughout the test.

c. The INS shall be allowed to navigate for 84 minutes.

d. Step b. above shall be repeated after which the INS will be placed in the Navigate Mode and immediately rotated 90° at a rate of approximately 1-1/2 degrees/second to an east heading ± 1°.

e. Step c. above shall be repeated.

f. Steps d. and e. above, shall be repeated for each of the two remaining cardinal headings (south and west).

g. The above tests shall be accomplished a total of three times. Gyro drifts shall be computed from the position and velocity error data. Shifts in drift with respect to change in headings shall be calculated.

50.4.1.6 Navigation Accuracy Under Scorsby Motion.

a. The test shall be performed with the INU mounted on a Scorsby table or 3-axis table.

b. The INS shall be maintained in a power-off condition for two hours minimum prior to start of this test.

c. With the test table level and stationary, the INS shall be aligned using the prescribed gyrocompass alignment procedure with the INU mount aligned north $\pm$ 1°.

d. The INS shall be put into the Navigate Mode after which a Scorsby motion of $\pm$ 3° amplitude at 6 cpm is applied within one minute and the INS allowed to navigate for 84 minutes minimum. Position and velocity shall be recorded at least once each minute.

e. Steps c. and d. above, shall be accomplished 3 times. The recorded data shall be analyzed to determine if the INS meets the position and velocity accuracy requirements of the specification.

50.4.1.7 Moving Base Alignment Test. The purpose of this test is to evaluate the sensitivity of the INS alignment to base (mount) motions which can be quantitatively described and which reasonably simulate actual motions that can be expected at the base of the INU mount during the aircraft preflight activities. Perform a gyrocompass alignment test (para. 50.4.1.1, 6 runs at 70°F) with the INS mounted on a single axis horizontal vibration table. The table shall be driven sinusoidally in the North-South direction only, at one CPS, one inch peak-to-peak (equivalent to .05g zero-to-peak). At the least opportune moment (determine by analysis) during alignment, add an additional motion, a 2 cm step in .5 second.

50.4.1.8 Attitude Accuracy in the Navigate Mode. The attitude readout parameters are heading, roll, and pitch. The following test steps shall be performed to accurately measure the attitude readout performance:

a. The test shall be performed with the system mounted on a precision table (accuracy $<1/4$ arc-min.).

b. System calibration shall be performed immediately prior to the test.

c. Perform gyrocompass alignment.

d. The system shall be switched to the navigate mode. Velocity components, platform azimuth, heading, roll and pitch shall be recorded once per minute throughout the test.

e. The INU shall be rotated 360° in azimuth in increments of 20°. The system indicated heading and the precision table readout will be recorded.

f. The INU shall be rotated $\pm$ 20° in pitch in increments of 4°. The indicated pitch and the precision table readout shall be recorded.

g. The INU shall be rotated $\pm$ 20° in roll in increments of 4°. The indicated roll and the precision table readout shall be recorded.

h. The system shall be operated continuously in the navigate mode during azimuth pitch and roll rotations for a minimum of 84 minutes.

i. This test procedure shall be accomplished a minimum of three times to insure repeatability of results.

A time history of the system platform tilt errors (or direction cosine tilt errors in the case of a strapdown) shall be reconstructed from the velocity error data. A constant azimuth drift will be assumed. Attitude readout error is attitude readout minus precision table readout adjusted for calculated platform tilt error (or direction cosine tilt errors in the case of a strapdown.) The heading error versus heading, pitch error versus pitch, and roll error versus roll shall be computed and plotted. One sigma values of error for each parameter shall be computed. The limiting factors in the performance of this test are east gyro and accelerometer bias calibration errors.

50.4.1.9 Acceleration Accuracy in the Navigate Mode. The acceleration parameters are the three axes acceleration errors. Data shall be collected over 84 minutes (one Schuler period) during the six gyrocompass alignment tests performed at 70°F (21.1°C). The indicated system acceleration will be the acceleration error since the system is stationary with respect to the earth.

A time history of the acceleration errors following each gyrocompass alignment shall be plotted.

50.4.1.10 Velocity Accuracy in the Navigate Mode. The velocity parameters are the three axes velocity errors. Data shall be collected over 84 minutes (one Schuler period) during the six gyrocompass alignment tests performed at 70°F (21.1°C). The indicated system velocity shall be the velocity error since the system is stationary with respect to the earth.

A time history of the velocity error following each gyrocompass alignment shall be plotted.

50.4.1.11 Present Position Accuracy in the Navigate Mode. The position parameters are latitude, longitude and altitude errors. Data shall be collected over 84 minutes (one Schuler period) during all gyrocompass alignment tests. The indicated system position minus the known laboratory position shall be the position error since the system is stationary with respect to the earth.

A time history of the position error following each gyrocompass alignment shall be plotted.

50.4.1.12 Azimuth - Acceleration and Rate. The azimuth - acceleration/rate parameters are the maximum azimuth acceleration and maximum azimuth rate existent in the flight environment. The following test steps shall be performed to accurately measure system performance following maximum azimuth perturbations:

a. The test shall be performed with the system mounted on a 3-axis table.

b. The system shall be aligned using the prescribed gyrocompass alignment procedure and switched to the navigate mode.

c. The system shall be rotated clockwise (See Figure V -1) in azimuth at the maximum acceleration until the maximum rate is achieved. The maximum rate shall be maintained for a rotation of 10°. The system shall then be decelerated at the maximum acceleration rate until motion ceases.

d. Following rotation, the system shall remain in the navigate mode for a period not less than 84 minutes. System indicated horizontal position and velocity shall be recorded once per minute.

e. The above procedure shall be repeated with the system rotated in a counter-clockwise direction.

f. Each test shall be accomplished a minimum of two times to insure repeatability of results.

A time history of horizontal position and velocity errors indicated by the system during each test shall be plotted. These results will be compared with the results of the previous gyrocompass alignment tests to determine the effects of azimuth acceleration/rate inputs.

50.4.1.13 Pitch-Acceleration and Rate. The pitch-acceleration/ rate parameters are the maximum pitch acceleration and maximum pitch rate existent in the flight environment. The following test steps shall be performed to accurately measure system performance following maximum pitch perturbations:

a. The test shall be performed with the system mounted on a 3-axis table.

b. The system shall be aligned using the prescribed gyrocompass alignment procedure and switched to the navigate mode.

c. The system shall be rotated upward (See Figure V -2) in pitch at the maximum acceleration rate until the maximum rate is achieved. The maximum rate shall be maintained for a rotation of 10°. The system shall then be decelerated at the maximum acceleration rate until motion ceases.

d. Following rotation, the system shall remain in the navigate mode for a period not less than 84 minutes. System indicated horizontal position and velocity shall be recorded once per minute.

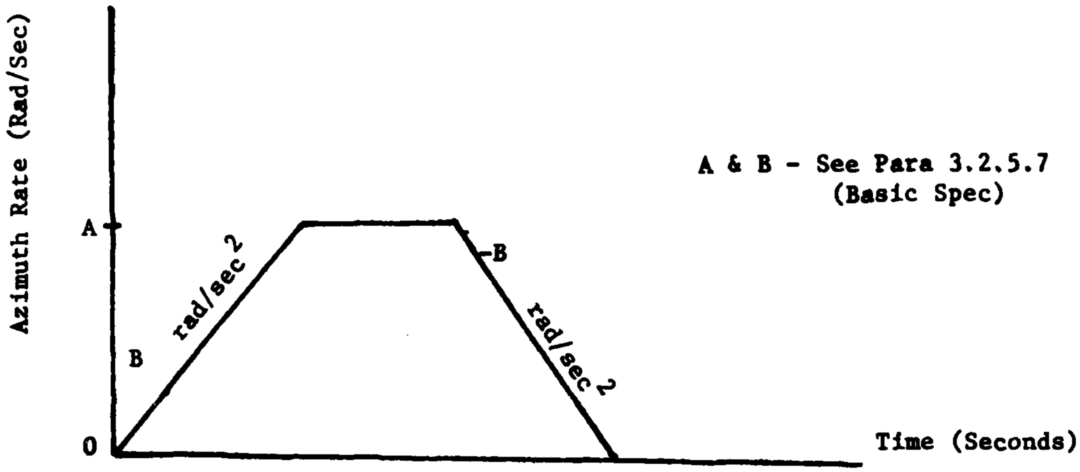


FIGURE V -1 AZIMUTH - ACCELERATION AND RATE

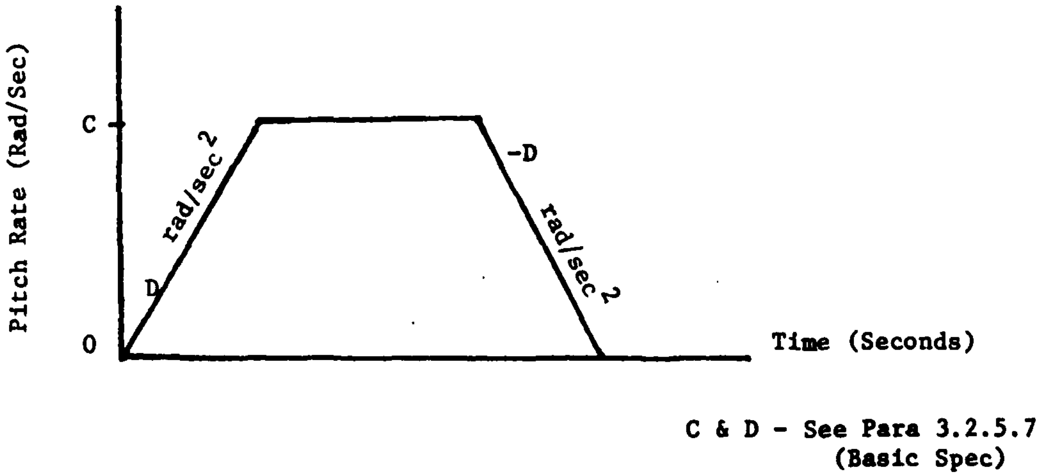


FIGURE V-2 PITCH - ACCELERATION AND RATE

e. The above procedure shall be repeated with the system rotated in a downward direction.

f. Each test shall be accomplished a minimum of two times to insure repeatability of results.

A time history of horizontal position and velocity errors indicated by the system during each test shall be plotted. These results shall be compared with the results of the previous gyrocompass alignment tests to determine the effects of pitch acceleration/rate inputs.

50.4.1.14 Roll - Acceleration and Rate. The roll-acceleration/rate parameters are the maximum roll acceleration and maximum roll rate existent in the flight environment. The following test steps shall be performed to accurately measure system performance following maximum roll perturbations:

a. The test shall be performed with the system mounted on a 3-axis table.

b. The system shall be aligned using the prescribed gyrocompass alignment procedure and switched to the navigate mode.

c. The system shall be rotated clockwise (See Figure V-3) in roll at the maximum acceleration rate until the maximum rate is achieved. The maximum rate shall be maintained for a rotation of 10°. The system shall then be decelerated at the maximum acceleration rate until motion ceases.

d. Following rotation, the system shall remain in navigate mode for a period not less than 84 minutes. System indicated horizontal position and velocity shall be recorded once per minute.

e. The above procedure shall be repeated with the system rotated in a counter-clockwise direction.

f. Each test shall be accomplished a minimum of two times to insure repeatability of results.

A time history of horizontal position and velocity errors indicated by the system during each test shall be plotted. These results shall be compared with the results of the previous gyrocompass alignment tests to determine the effects of roll acceleration/rate inputs.

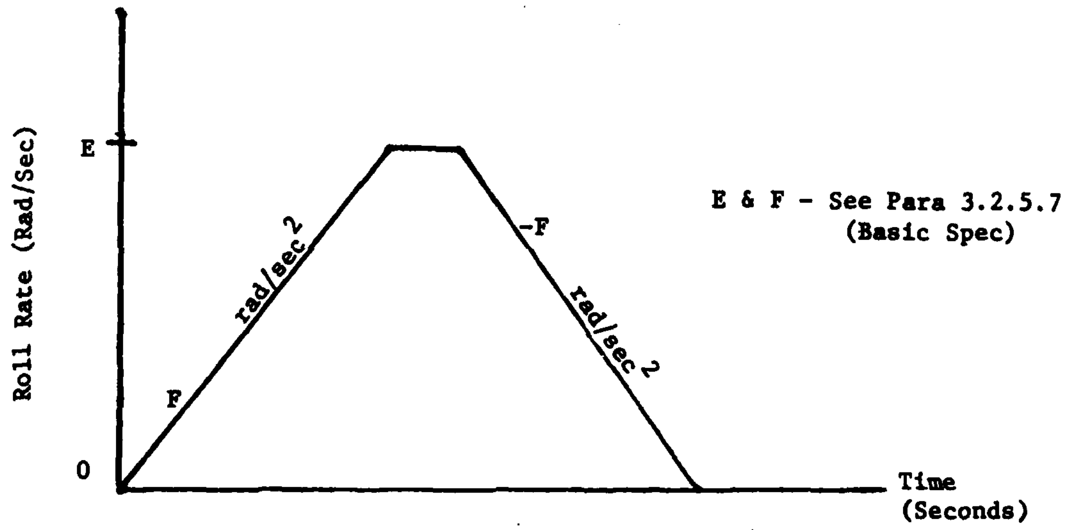


FIGURE V-3 ROLL-ACCELERATION AND RATE

50.4.1.15 Parameter Update Test. During this test series, update command shall be inputted to the INS through the data bus and a digital output (Appendix II) shall be recorded on magnetic tape once per second except for the 84 minute navigation runs (Step c.) which shall be once per minute.

a. Align the INU and switch to the navigate mode. Introduce each of the following incremental changes and record output for 30 seconds, then introduce the negative change of the same quantity and record data for 30 seconds. Each parameter shall be updated individually, in the order listed:

PARAMETER	EQUIVALENT STEP
V_x	$\pm$ 4 fps
V_y	$\pm$ 4 fps
V_z	$\pm$ 4 fps
Lat	$\pm$ 2 arc-min
Long	$\pm$ 2 arc-min
Altitude	$\pm$ 500 ft
C_{xx}	$\pm$ 2 arc-min
C_{xy}	$\pm$ 2 arc-min
C_{xz}	$\pm$ 2 arc-min

b. Realign the INS (no cool down required), switch to the navigate mode and navigate for 10 minutes. Command the INU to torque the platform +10 arc-min about the X-axis. After 30 seconds command the INU to torque the platform -10 arc-minutes about the X-axis. Continue to navigate for 10 minutes. Command the INU to torque the platform +10 arc-min about the Y-axis. After 30 seconds, command the INU to torque the platform -10 arc-min about the Y-axis. Continue to navigate for 10 minutes.

c. Realign the INS (no cool down required), switch to the navigate mode and static navigate for 10 minutes. Command the INU to change X-gyro drift bias by +.02°/hr, navigate for 84 minutes, command the INU to change X-gyro bias by -.02°/hr, navigate for 84 minutes. Realign and repeat for a Y-gyro drift bias of $\pm$.02°/hr. Realign and repeat for a Z-gyro drift bias of $\pm$.05°/hr.

50.4.1.16 Linear Acceleration - Normal Load. The purpose of this test is to evaluate performance sensitivity to linear acceleration. The following test steps shall be performed:

a. The test shall be performed with a system mounted on a centrifuge.

b. The INS shall be prepared in accordance with pre-test performance requirements, paragraph 50.3.2.1. Upon completion of a gyrocompass alignment conduct ten minutes of static navigation.

c. The system shall be maintained in the navigation mode during acceleration and for 84 minutes after each acceleration. Record system horizontal position and velocity once per minute for each test.

d. With the case oriented to simulate an aircraft in vertical flight which is experiencing a positive normal acceleration relative to airframe axis, centrifuge a steadily increasing g-load on the test item peaking at +12 g and then returning 0 g. Total test time is limited to 10 minutes with 30 seconds maximum time at +12 g. Angular rate should not exceed 7 radians/second at any time.

Rotate the case 180° about the vertical axis, then centrifuge a steadily increasing g-load on the test item peaking at +3 g and returning to zero. Time and angular rate limitations same as the previous paragraph.

e. With the case oriented to simulate an aircraft in horizontal flight which is experiencing forward acceleration relative to airframe axis, centrifuge a steadily increasing acceleration on the test item peaking at 3 g's. Total test time is limited to 5 minutes and the angular rate should not exceed 3 radians/seconds at any time.

Rotate the case 90° about the vertical axis, then centrifuge a steadily increasing g-load on the test item peaking at 1.5 g's and returning to zero. Time and angular rate limitations are as listed in the above paragraph.

Rotate the case 180° from its original position about a vertical axis, then centrifuge a steadily increasing g-load on the test item peaking at -3 g's and returning to zero. Time and angular rate limitations are as listed in the above paragraph.

Rotate the case 270° from its original position about a vertical axis, then centrifuge a steadily increasing g-load on the test item peaking at 1.5 g's and then returning to zero. Time and angular rate limitations are as listed in the above paragraph.

A time history of horizontal position and velocity errors indicated by the system during each test shall be plotted. These results shall be compared with the specified position and velocity accuracy requirements.

50.4.2 Aircraft Test. The primary purpose of the aircraft test series is to determine the expected system performance in an actual aircraft application. In general, the flight test series shall not test the system to the environmental extremes of the specification. Furthermore, the flight test series shall not be a series of specific tests to test specific performance parameters; but rather, a series of general flight profiles similar to actual system used in an aircraft. The results of these tests shall be statistically analyzed to derive the desired figures of merit.

Test Installation. The system shall be installed in an aircraft test pallet. This pallet shall provide the necessary instrumentation and interface between the test item, test aircraft, and data acquisition system. The test item shall be operated to determine that no malfunction or damage was caused due to installation or handling. This operation shall consist of aligning the system and performing static navigation.

Test Performance. The test item shall be maintained in the power-off condition for a period of not less than two hours at aircraft conditions prior to test. The test item shall be turned on 50 minutes before scheduled engine start-up or aircraft first motion. The system shall then be aligned and tested in accordance with applicable test requirements. System self-calibration shall be performed throughout the aircraft test series in accordance with the operational calibration schedule.

Post-Test Evaluation. At the completion of each test, the test data shall be compared with the pre-test data.

50.4.2.1 Transport Test Series. The main objective of the transport test series is to measure navigation accuracy (position and velocity) on short and moderate duration missions, for the primary (gyrocompass) alignment mode. Secondary objectives are to demonstrate the other alignment modes and to demonstrate additional features such as steering and position updates.

The tests in the transport test series are shown in Table V-1. The aircraft follows the flight path specified in Table V-1 and as shown in Figure V-4. The flight paths are precisely defined by a chain of surveyed ground check-points. These are the same ground check-points used by the photo-reference system. The cruise altitude shall be approximately 20,000 feet MSL when the camera reference system is used and 30,000 feet MSL for the CIRIS reference system.

Throughout each test, operator observable data from the CDU shall be manually recorded to provide back-up performance data and real-time quick-look data. The turn around point, for each flight, is chosen to make the outbound leg duration either one or two Schuler periods as specified in Table V-1. The system continues to navigate for 45 minutes after landing. The specific tests in the transport series may be performed in any order.

50.4.2.1.1 Calibration.

a. Prior to commencing transport aircraft testing a self-calibration will be accomplished in an aircraft environment with the INS integrated with the aircraft test instrumentation. Orientation of the aircraft for this calibration shall be East.

b. During the transport aircraft test series, self-calibrations shall be accomplished in the aircraft in accordance with scheduled maintenance requirements.

c. During the transport aircraft test series, a self-calibration will be accomplished in the aircraft at the TDY location during the RON flight test listed in Table V-1, to assure that the self-calibration can produce acceptable navigation performance if the calibration is accomplished at different sites.

50.4.2.1.2 Gyrocompass Alignment (Aircraft/Ground). Six stationary aircraft tests shall be performed. The following test steps shall be performed to accurately measure the gyrocompass alignment performance during stationary aircraft tests:

a. The test shall be performed with the system mounted on a test pallet. If required, initial heading will be obtained from the aircraft air data computer.

TABLE V-1 TRANSPORT TEST SERIES

Number of Tests Reqd	Description	Nominal Time (Hrs)
6	Static navigation runs in aircraft, gyrocompass alignments, 3 pointing north, 3 pointing east	2
6	West/east 84 minute cruise profiles with gyrocompass alignment	3
6	North/south 84 minute cruise profiles with gyrocompass alignment	3
2	North/south racetrack patterns with gyrocompass alignment, 6 minute legs, 3 laps (CIRIS required)	2
1	84 minute cruise profile, stored heading alignment with overfly position update demonstration	3
1	84 minute cruise profile, stored heading alignment with steering check (CIRIS required)	3
1	84 minute cruise profile, bath alignment with overfly position update demonstration	3
3	North/south 168 minute cruise profile with gyrocompass alignment	6
3	East/west 168 minute cruise profile with gyrocompass alignment	6
1	Fly to distant point, RON, and return	4 out/4 return
3	East/west 84 minute cruise profiles with gyrocompass alignment	3

NOTE: UTM coordinate mode will be demonstrated during cruise profile.

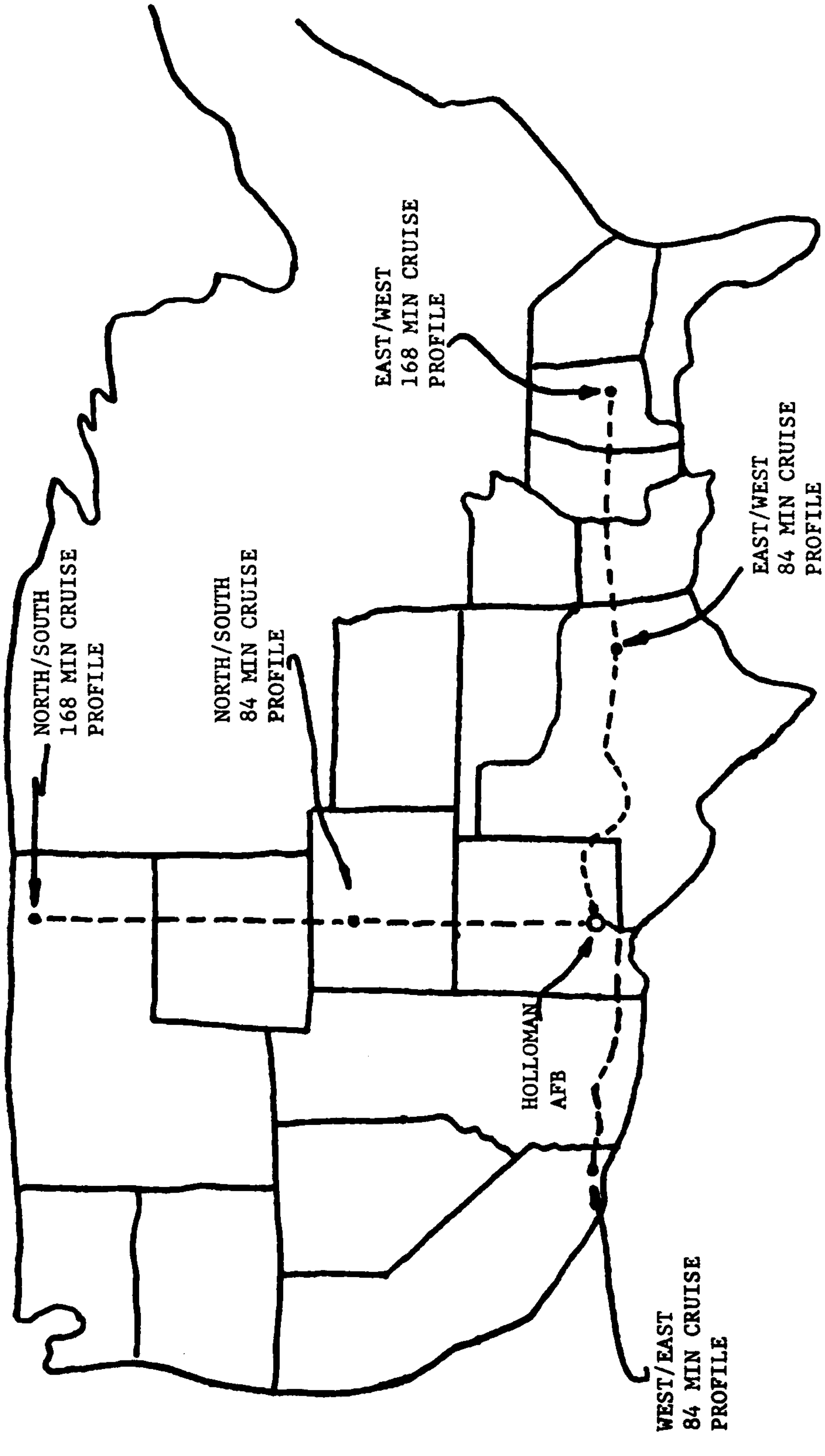


FIGURE V-4 CHECKPOINT FLIGHT PATHS

b. The system shall be aligned using the prescribed gyrocompass alignment procedure. Aircraft motion shall be monitored and recorded during alignment with an accelerometer triad mounted directly adjacent to the system on the test pallet. Alignment status, attitude and calibration parameters being updated shall be recorded six times per minute during the alignment sequence. Position and velocity shall be recorded once per minute throughout the test.

c. Following alignment, the system shall be switched to the navigate mode for a period not less than 84 minutes without moving the aircraft. The test shall be accomplished a minimum of three times with the aircraft heading north and three times with the aircraft heading east to observe the effects of buffeting on the accelerometers and to insure repeatability of results. At least one test at each heading shall be for a duration of four hours to verify long term operation in the aircraft environment prior to commencing flight tests and to provide a baseline of static performance for typical flight tests. During alignment, the north and east tilt should compensate for the east and north accelerometer biases and the azimuth error should compensate for the east gyro drift. Compensation errors shall be computed from velocity data recorded during the 84 minute navigation mode operation. The effects of aircraft motion on gyrocompass alignment shall be observed together with power spectral density plots of aircraft motion. Alignment status, attitude and calibration parameters that are being updated shall be analyzed as well as an estimate made of gyrocompass alignment errors. Position and velocity errors that occur during static navigation runs shall be plotted and analyzed to determine if the INS meets specification accuracy requirements.

50.4.2.1.3 Gyrocompass Alignment (Aircraft/Ground/Flight). Two race track flight tests shall be performed. The following test steps will be performed to accurately measure the gyrocompass alignment performance during aircraft flight tests:

a. The test shall be performed with the system mounted on a test pallet. If required, initial heading will be obtained from the aircraft air data computer.

b. The system shall be aligned using the prescribed gyrocompass alignment procedure.

c. Following alignment, the system shall be switched to the navigate mode. Indicated velocity and position shall be recorded throughout the test.

The objective of the gyrocompass alignment flight tests is to measure heading error independent of east gyro drift. A north-south race track flight path with six minute legs will be flown. The east velocity error (system versus reference) versus time shall be computed and plotted. Heading error shall produce incremental steps in each velocity error at the 180° turns. The heading error shall be computed from the magnitude of the increment in each velocity error and the speed of the aircraft.

50.4.2.1.4 System Alignment Orientations. The system alignment for the eighteen cruise profiles with gyrocompass alignments shall be evenly distributed between north and east orientations.

50.4.2.1.5 Backup Attitude. On one flight test, the backup attitude mode shall be initiated in flight and roll, pitch and heading compared to CIRIS - indicated roll, pitch and heading for 5 minutes minimum. This test shall include a landing maneuver.

50.4.2.1.6 Stored Heading Alignment. The purpose of this flight test is to verify that the system can determine position and velocity while in an autonomous navigation mode after being aligned with a stored heading. The following test steps shall be performed.

a. The system shall be aligned using the prescribed gyrocompass alignment procedure.

b. The system shall be turned off for two hours and then back on.

c. The system shall be aligned using the prescribed stored heading alignment procedure.

d. The system shall be switched to the navigate mode for a flight of not less than 84 minutes. Indicated velocity and position shall be recorded throughout the flight.

A time history of velocity and position errors shall be plotted to determine system performance when aligned with a stored heading.

50.4.2.1.7 Best Available True Heading Alignment. The purpose of the flight test is to verify that the system can determine position and velocity while in an autonomous navigation mode after being aligned with the best available true heading. The following steps shall be performed:

a. The system shall be aligned using the prescribed gyrocompass alignment procedure.

b. The system shall be turned off for two hours and then back on.

c. The system shall be aligned using the prescribed best available true heading alignment procedure. The best available true heading shall be the system indicated heading at the completion of gyrocompass alignment.

d. The system shall be switched to the navigate mode for flight of not less than 84 minutes. Indicated velocity and position shall be recorded through the flight.

A time history of velocity and position errors shall be plotted to determine system performance when aligned with the best available true heading.

50.4.2.1.8 Steering. Steering checks shall be performed on one flight. Steering outputs of course, range, time to destination, ground track, and steering error for ten predetermined destinations shall be verified by flight against known ground checkpoints. These checks shall be made on the return leg of a cruise profile flight.

50.4.2.1.9 Magnetic Heading. The magnetic heading and true heading shall be recorded and the difference shall be compared to known values of magnetic variation.

50.4.2.1.10 Overfly Position Navigation Update. Overfly position updates shall be used on two flights. On the return leg, shortly after turnaround, the coordinates of a ground checkpoint shall be entered into the INS. The aircraft shall be directed over the checkpoint and the update shall be made when the checkpoint crosses the transverse crosshair of the down-looking viewfinder. Four additional position updates will be made and a final update after landing, just prior to turning the system off.

50.4.2.1.11 <u>UTM Mode</u>. On one race track profile flight test, UTM grid coordinates shall be recorded at least once per minute. For reference CIRIS data interpolated to system measurement times shall be converted to UTM grid coordinates. Total error is expressed as system output minus reference. As a verification of the algorithm, system output in geographic coordinates shall be converted to UTM grid coordinates and subtracted from UTM output. This is a measure of algorithm accuracy.

50.4.2.2 <u>Fighter Test Series</u>. The objective of the fighter test series is to measure the navigation accuracy of the test item(s) while exposed to the more severe dynamic and vibrational environment of a high performance aircraft. The fighter test series is shown in Table V-2.

50.4.2.2.1 <u>Calibration</u>.

a. Prior to commencing fighter aircraft testing, a self-calibration shall be accomplished in an aircraft environment with the INS integrated with the aircraft test instrumentation. The fighter shall be oriented East during this test.

b. The only other self-calibrations to be accomplished during the fighter aircraft test series will be in accordance with scheduled maintenance requirements.

50.4.2.2.2 <u>Gyrocompass Alignment</u>. Perform same gyrocompass alignment tests in the fighter aircraft as was performed in the transport aircraft (Ref. para. 50.4.2.1.2).

50.4.2.2.3 <u>System Alignment Orientation</u>. The system alignment for the eighteen cruise profiles with gyrocompass alignment shall be evenly divided between north and east orientations.

50.4.2.2.4 <u>Stored Heading Alignment</u>. Perform same stored heading alignment flight test in the fighter aircraft as was performed in the transport aircraft (Ref. para. 50.4.2.1.6).

50.4.2.2.5 <u>Best Available True Heading Alignment</u>. Perform same best available true heading alignment flight test in the fighter aircraft as was performed in the transport aircraft (Ref. para. 50.4.2.1.7).

TABLE V-2 FIGHTER TEST SERIES

Number of Tests Reqd	Description	Nominal Time (Hrs)
6	Static Navigation runs in aircraft, gyrocompass alignments, 3 pointing north, 3 pointing east	2
6	West/east 42 minute cruise profile, gyrocompass alignment	1-1/2
6	West/east 42 minute cruise profile, gryocompass alignment and 9 minute simulated ordnance delivery	1-1/2
6	West/east 42 minute cruise profile, gyrocompass alignment and 9 minute simulated air combat	1-1/2
1	West/east 42 minute cruise profile, stored heading alignment	1-1/2
1	West/east 42 minute cruise profile, bath alignment	1-1/2

50.4.2.3 Helicopter Test Series. Table V-3 and Figure V-5 defines the tests to be conducted during this phase of testing. Two basic types of flight profiles are flown during this test phase: both North-South and East-West navigation profiles, and terrain mapping profiles. The navigation flight profiles shall be flown in order to obtain baseline navigation data in straight and level flight. These flights are made at 750-1000 foot altitudes above ground level. They are made with 180° turns coinciding with a half Schuler period (42 minutes). The terrain mapping profiles are designed to simulate operational conditions as closely as possible. Specific maneuvers include: low level cruising, low level hover, landing between maneuvers, autogyro descent from altitude, attack and evasion profiles, and mapping profiles. The normal duration of each mission is 1-1/2 - 2 hours.

a. Prior to commencing helicopter aircraft testing, a self-calibration shall be accomplished in the helicopter with the INS integrated with the aircraft test instrumentation. The helicopter shall be oriented East during this calibration.

b. The only other self-calibrations to be accomplished during the helicopter aircraft test series shall be in accordance with scheduled maintenance requirements.

50.4.2.3.1 Gyrocompass Alignment. Perform same gyrocompass alignment tests in the helicopter as was performed in the transport aircraft (Ref. para. 50.4.2.1.2).

50.4.2.3.2 System Alignment Orientation. The system alignment for the twelve cruise profiles with gyrocompass alignment shall be evenly divided between north and east orientations.

50.4.2.3.3 Stored Heading Alignment. Perform same stored heading alignment flight test in the helicopter as was performed in the transport aircraft (Ref. para. 50.4.2.1.6).

50.4.2.3.4 Best Available True Heading Alignment. Perform same best available true heading alignment flight test in the helicopter as was performed in the transport aircraft (Ref. para. 50.4.2.1.7).

50.4.2.4 Test Instrumentation. Each flight pallet shall be equipped with a computer and a digital recorder. The serial digital data from each INS mode of operation (refer to paragraph 3.2.1.9 and Appendix II in this document) shall be stored, manipulated, and displayed as required.

TABLE V-3 HELICOPTER TEST SERIES

Number of Tests Reqd	Description	Nominal Time (Hrs)
6	Static Navigation runs in aircraft gyrocompass alignment, 3 pointing north, 3 pointing east	2
6	East/West 42 min cruise profiles, gyrocompass alignment	1-1/2
6	North/South 42 Min cruise profiles, gyrocompass alignment	1-1/2
6	East Terrain mapping missions, gyrocompass alignment	1-1/2
1	North/South 42 min cruise profiles, stored heading alignment	1-1/2
1	North/South 42 min cruise profiles, BATH alignment	1-1/2

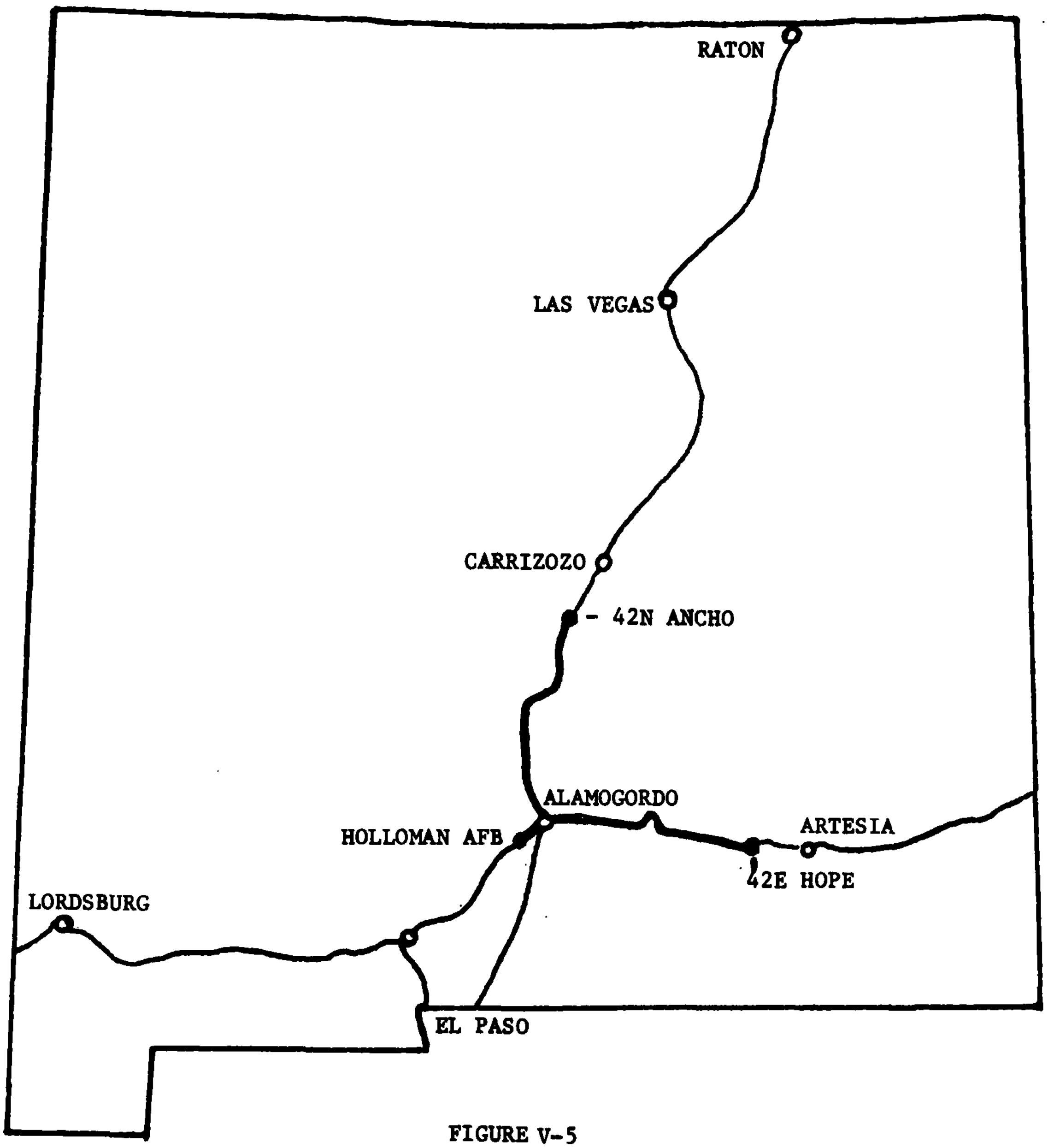


FIGURE V-5

HELICOPTER FLIGHT PATHS

The testbed parameters listed in Table V-4 shall be monitored, formatted, and stored for reference.

50.4.2.4.1 Reference Instrumentation. The reference data for the analysis shall be provided by either the Completely Integrated Reference Instrumentation System (CIRIS), the camera reference system, or range radar tracking data.

The CIRIS is an aided inertial navigation which utilizes ground based transponder stations, an airborne interrogator, and a real-time Kalman filter.

The camera reference system consists of a fixed aerial camera, a down-looking viewfinder system, and an attitude/heading reference system.

The radar reference system consists of a C-band transponder in the testbed and ground based radar tracking stations.

50.4.2.5 Analysis. The digital magnetic tapes of the recorded system data, the testbed data, and the reference navigation data shall be analyzed to obtain the system performance. System performance figures of merit shall be determined as shown in Table V-5.

TABLE V - 4 DATA ACQUISITION REQUIREMENTS

TESTBED PARAMETERS

IRIG Time Code

Camera Pulse Discrete

DC Voltage

ØA Voltage

ØB Voltage

ØC Voltage

ØA Frequency

Temperature

Humidity

Vibration

Cooling Temperature

Cooling Humidity

Cooling Flow

True Air Speed

TABLE V-5 SYSTEM PERFORMANCE REPORTING

	TRANSPORT					FIGHTER					HELICOPTER				
	Std Deviation	50% vs Time	90% vs Time	95% vs Time	Other	Std Deviation	50% vs Time	90% vs Time	95% vs Time	Other	Std Deviation	50% vs Time	90% vs Time	95% vs Time	Other
GYROCOMPASS ALIGNMENT ERRORS	X					X					X				
BACKUP ATTITUDE ERRORS	X														
*TRUE HEADING ERROR					X										
HORIZONTAL VELOCITY ERROR		X	X		X		X	X		X		X	X		X
VERTICAL VELOCITY ERROR	X					X					X				
HORIZONTAL POSITION ERROR		X	X	X			X	X	X			X	X	X	
**ALTITUDE ERROR	X					X					X				
DRIFT ANGLE					V										
WIND SPEED					V										
WIND DIRECTION					V										
STEERING					V										
UTM I/O					V										
MAGNETIC HEADING					V										
TARGET STORED					V										

* Two Samples
** Determined from data during landing only
V Verify function

APPENDIX VI

INS MESSAGE FORMAT

60.1 SCOPE AND PURPOSE

60.1.1 Scope. This appendix defines requirements for the multiplex data bus portion of the INS hardware. Conventional stand alone navigation systems are discussed. Systems where the INU is integrated with a central computer are discussed.

60.1.2 Purpose. The purpose of this document is to establish uniform requirements for an INS which uses multiplex data buses as interface devices. A secondary purpose is to identify unique subaddress codes and data message word and bit assignments. The document will promote technical interchange by further defining digital interfaces.

60.2 APPLICABLE DOCUMENTS

STANDARDS

MIL-STD-1553A 30 Apr 75	Aircraft Internal Time Division Command/Response Multiplex Data Bus

SPECIFICATIONS

MIL-E-6051D(1) 05 Jul 68	Electromagnetic Compatibility Requirements Systems

60.3 DEFINITIONS

In accordance with MIL-STD-1553A.

60.4 REQUIREMENTS

60.4.1 INS/Data Bus Operation. When operating as a remote terminal, the INS components shall conform to the data bus operation (MIL-STD-1553A). Sole control of information transmission shall reside with the bus controller which shall initiate all transmissions. In the second configuration, a bus controller may be implemented in the INU (as defined in 60.4.6).

60.4.1.1 Information Transfer Modes. The INU component shall respond only to the following three modes of information transfer: (1) Bus controller to remote terminal (RT) transfer; (2) RT to controller transfer; (3) RT to RT transfer. These modes shall be operated as described in 60.4.2.3.6.

60.4.2 Characteristics

60.4.2.1 Data Form. Digital data shall be transmitted in a form compatible with the message and word formats defined in Table VI-8. Negative quantities shall follow the 2's complement convention. Data bit number "1" as defined in Table VI-8 shall be the most significant bit and data bit "16" shall be the least significant bit. Word formats which define least significant bits to a higher resolution than the computational capability of the INU shall be filled with logic zeros subsequent to the least significant INU computed bit.

These message and word formats will be compatible with the subaddress codes. Other message and word formats may be developed for other applications.

60.4.2.2 Bit Priority. The most significant bit shall be transmitted first with the less significant bits following in descending order of value. The number of bits required to define a quantity shall be consistent with the resolution or accuracy required. In the event double precision quantities (information accuracy or resolution requiring more than 16 bits) are transmitted, the more significant half shall be transmitted first, followed by the less significant half.

60.4.2.3 Transmission Method

60.4.2.3.1 Modulation. The signal shall be transferred over the data bus in serial digital pulse code modulation form.

60.4.2.3.2 Data Code. The data code shall be Manchester bi-phase level. A logic one shall be transmitted as a bi-polar coded signal 1/0 (i.e., a positive pulse followed by a negative pulse). A logic zero shall be bi-polar coded signal 0/1 (i.e., a negative pulse followed by a positive pulse). A transition through zero occurs at the midpoint of each bit time.

60.4.2.3.3 Transmission Rate. The transmission rate on the bus shall be 1.0 megabit per second with a long term stability of ± 0.01 percent (i.e., ± 100 Hz). The short term stability (i.e., stability over a 1.0 second interval) shall be at least 0.001 percent (i.e., ± 10 Hz).

60.4.2.3.4 Word Size. The word size shall be 16 bits plus the sync waveform and the parity bit for a total of 20 bit times.

60.4.2.3.5 Word Formats. The word formats shall be as shown on Figure 3 of MIL-STD-1553A for the command, data, and status words.

60.4.2.3.5.1 Command Word. A command word shall be comprised of a sync waveform, address, transmit/receive bit, subaddress/mode, data word count/mode code, and a parity bit, except as modified by 60.4.2.3.5.1.7.

60.4.2.3.5.1.1 Sync. The command sync waveform shall be an invalid Manchester waveform. The width shall be three bit times, with the waveform being positive for the first one and one-half bit times, and then negative for the following one and one-half bit times. If the next bit following the sync is a logic zero, then the last half of the sync waveform will have an apparent width of two clock periods due to the Manchester encoding.

60.4.2.3.5.1.2 Address. The next five bits following the sync shall be the RT address. This permits a maximum of 32 RT's to be attached to any one data bus. All 1's shall indicate a decimal address of 31 and shall not be used. All 0's shall indicate a decimal address of 32. The most significant bit of the address shall be transmitted first.
60.4.2.3.5.1.2.1 Unique Address. Selection of the specific address shall be determined by the presence or absence of continuity between pins on the INS components input-output connectors. The presence or absence of continuity shall be established in the vehicle wiring. The INS addresses shall be established in the vehicle wiring. A zero condition will be indicated by pin to ground continuity. All five pins shall be connector programmable. See Table VI-2 for allocated address assignments.

60.4.2.3.5.1.3 Transmit/Receive. The next bit following the address shall be the transmit/receive bit, which shall indicate the action required of the RT. A logic zero shall indicate the RT is to receive, and a logic one shall indicate the RT is to transmit.

60.4.2.3.5.1.4 Subaddress/Mode. The next five bits following the transmit/receive bit shall be utilized for either a RT subaddress or mode control, as is dictated by the individual terminal requirements. The subaddress/mode values of 00000 and 11111 are reserved for special purposes, as specified in 60.4.2.3.5.1.7, and shall not be utilized for any other function.

60.4.2.3.5.1.5 Word Count/Mode Code. The next five bits following the subaddress/mode control shall be the quantity of data words to be either sent out or received by the RT, with the exceptions specified in paragraph 60.4.2.3.5.1.7. A maximum of 32 data words may be transmitted or received in any one message block. All 1's shall indicate a decimal count of 31, and all 0's shall indicate a decimal count of 32.

60.4.2.3.5.1.6 Parity. The last bit in the word shall be used for parity over the preceding sixteen bits. Odd parity shall be utilized.

60.4.2.3.5.1.7 Mode Control. A subaddress/mode field bit pattern of 00000 or 11111 shall imply that the contents of the word count field are to be decoded as a five bit mode command. The data word count/mode code field bit patterns which are common to all subsystems shall be 00001, which indicates that the subsystem shall reset its timer, and 01000, which indicates that the subsystem shall reset/initialize its receiver logic. If a subsystem receives a mode control command with the word count field containing a bit pattern which that subsystem is not mechanized to execute, then the subsystem shall reset/initialize the receiver logic and respond with its status word. A word count field of all

zero's shall not be generated because of its use as dynamic bus allocation in other possible MIL-STD-1553A configurations.

60.4.2.3.5.1.8 Allocated Subaddress Mode. Table VI-2 lists INS subaddresses which have been allocated. Use of other subaddresses for the INS system shall be subject to approval by the procuring activity.

60.4.2.3.5.1.9 Instrumentation Bit. Bit 10 of the command word will be set to a "1".

60.4.2.3.5.1.10 Variable Message Block. The INS RT shall be able to transmit a subset of any message block defined in Table VI-2 (i.e., send the first n-x words of a message, where n is the defined word count of that message in Table VI-2 and $X \leq n-1$). This shall be done by varying the word count up to the maximum defined by a particular subaddress in Table VI-2.

60.4.2.3.5.2 Data Word. A data word shall be comprised of a sync waveform, data bits and a parity bit.

60.4.2.3.5.2.1 Sync. The data sync waveform shall be an invalid Manchester waveform. The width shall be three bit times, with the waveform being negative for the first one and one-half bit times, and then positive for the following one and one-half bit times. Note that if the bits preceding and following the sync are logic ones, then the apparent width of the sync waveform will be increased to four bit times.

60.4.2.3.5.2.2 Data. The sixteen bits following the sync shall be utilized for data transmission.

60.4.2.3.5.2.3 Parity. The last bit shall be utilized for parity as specified in 60.4.2.3.5.1.6.

60.4.2.3.5.3 Status Word. A status word shall be comprised of a sync waveform, RT address, message error bit, status codes, terminal flag bit and a parity bit. The INS components shall reset status word bits which are set. The status word bits, with the exception of the address, shall be cleared, i.e., set to logic zero, upon receipt of a valid command word by the RT.

60.4.2.3.5.3.1 Sync. The sync waveform shall be as specified in 60.4.2.3.5.1.1.

60.4.2.3.5.3.2 INS Component Address. The next five bits following the sync shall contain the address of the INS component which is transmitting the status word.

60.4.2.3.5.3.3 Message Error. The first bit (Bit 9) after the address shall be utilized to indicate that the preceding message failed to passthe RT's validity tests. This error condition shall

include parity errors. A logic one shall indicate the presence of a message error, and a logic zero its absence. A message error shall be indicated when the preceding message to an RT has failed either the word or message validity criteria for the RT. The criteria shall include those specified in 60.4.2.5.4.4.

60.4.2.3.5.3.4 Status Codes. All zeros shall indicate a normally functioning terminal. The next nine bits are defined below.

STATUS WORD	VALUE	FUNCTION
BIT TIME 10	0	Instrumentation Bit
BIT TIME 11	0	Undefined
BIT TIME 12	0	Undefined
BIT TIME 13	0	Undefined
BIT TIME 14	0	Undefined
BIT TIME 15	0	Undefined
BIT TIME 16	0	Undefined
BIT TIME 17	0	Undefined
BIT TIME 18	0	Undefined

Bits 10 through 18 shall always be transmitted as logic zeros. The definition of any undefined bit is subject to approval by the procuring activity.

60.4.2.3.5.3.5 Terminal Flag. Bit 19 is the status bit reserved for a terminal flag bit. This bit shall be set when INS components have failed or the data contained in the message is invalid. Failure conditions detected by reasonable checks, continuous test, and self tests except those included in the message error bit shall be included in the conditions which shall set the terminal flag bit. When Bit 19 is set, the Central Computer (Bus Controller) will reject all INS data for that input/output cycle.

This bit shall not be used to schedule periodic examination of self test data when no fault is present.

60.4.2.3.5.3.6 <u>Parity</u>. The last bit shall be utilized for parity as specified in 60.4.2.3.5.1.6.

60.4.2.3.6 <u>Message Formats</u>. The messages transmitted on the data bus shall be in accordance with the formats. The maximum and minimum response times shall be as stated in 60.4.3.1.

60.4.2.3.6.1 <u>Controller to RT Transfers</u>. The controller shall issue a receive command followed by the specified number of data words. The RT shall, after message validation, transmit a status word back to the controller. The command and data words shall be transmitted in a continuous fashion with no interword gaps.

60.4.2.3.6.2 <u>RT to Controller Transfers</u>. The controller shall issue a transmit command to the RT. The RT shall, after command verification, transmit a status word back to the controller, followed by the specified number of data words. The status and data words shall be transmitted in a continuous fashion with no interword gaps.

60.4.2.3.6.3 <u>RT to RT Transfers</u>. The controller shall issue a receive command to RT A, followed contiguously by a transmit command to RT B. RT B shall then transmit the status and data words as specified in 60.4.2.3.6.2 after which RT A shall transmit a status word as specified in 60.4.2.3.6.1.

60.4.2.4 <u>Transmission Line</u>. The data bus shall utilize, as the transmission medium, a twisted, shielded, wire pair.

60.4.2.4.1 <u>Cable</u>. The cable used shall be a two conductor, twisted, shielded, jacketed cable. The wire-to-wire distributed capacitance shall not exceed 30.0 picofarads per foot. The cable shall be formed with not less than one twist per inch; and the cable shield shall provide a minimum of 80 percent coverage.

60.4.2.4.2 <u>Characteristic Impedance</u>. The characteristic impedance shall be 70 ohms, plus or minus 10 percent, at a sinusoidal frequency of 1.0 Mhz.

60.4.2.4.3 <u>Cable Attenuation</u>. At the frequency of 60.4.2.4.2, the cable power loss shall be 1 db/100 ft. or less.

60.4.2.4.4 <u>Cable Length</u>. The cable length of any main bus may be up to 300 feet.

60.4.2.4.5 Cable Termination. The cable shall be coupled to the RT as shown in Figure 7 of MIL-STD-1553A. A long stub is defined as any stub greater than one foot in length. The use of long stubs is discouraged and the length of any stub shall not exceed 20 feet. The two ends of the cable shall be terminated with a resistance equal to the cable characteristic impedance.

60.4.2.4.6 Cable Coupling. All connections to the data bus shall utilize a small shielded coupler box. This box shall be of sufficient size to permit the installation of the transformer and isolation resistors specified in 60.4.2.5.

60.4.2.4.7 Wiring and Cabling for EMC. For purposes of electromagnetic compatibility (EMC), the wiring and cabling provisions of MIL-E-6051D shall apply.

60.4.2.5 RT/Bus Interface Circuits.

60.4.2.5.1 Circuit Configuration. The input/output circuits shall consist of a transmitter-receiver, DC isolation/coupling transformer, and isolation resistors.

60.4.2.5.2 Fault Isolation. An isolation resistor shall be placed in series with each connection to the data bus cable. This resistor shall have a value of 0.75 Z_o ohms plus or minus 5 percent where Z_o is the cable characteristic impedance. The impedance placed across the data bus cable shall be no less than 1.5 Z_o ohms for any failure of the coupling transformer, cable stub, or RT transmitter/receiver. The isolation resistors shall be located in the vehicle harness between the INS components connectors and the transmission cable.

60.4.2.5.3 RT Output Characteristics.

60.4.2.5.3.1 Output Levels. The RT signal output circuitry shall be capable of driving the cable specified in 60.4.2.4.1 and not less than 33 other RT's, as specified herein, each attached to the cable by means of a cable stub of maximum length specified in 60.4.2.4.5. The output circuitry shall maintain the specified operation with the exception of a 25 percent maximum reduction of the data bus signal amplitude in the event that one of the RT's has a fault that causes it to reflect the fault impedance specified in 60.4.2.5.2 on the bus. The RT signal output voltage shall be plus or minus 12.0 volts, peak, line-to-line, ± 10 percent, when measured at the RT output, terminated into a 70 ohm ± 5 percent resistive load.

60.4.2.5.3.2 Output Waveform. The waveform, when observed at Point C in Figure 7 of MIL-STD-1553A, shall have zero crossing which deviates not more than plus or minus 25 nanoseconds from those shown in Figure 8 of MIL-STD-1553A. The rise and fall time of this waveform shall be equal to or greater than 100 nanoseconds when measured from levels of 10 to 90 percent of full waveform peak-to-peak voltage as shown in Figure 8, MIL-STD-1553A. Any distortion of the waveform including overshoot and ringing shall not exceed 1.2 volts peak, line-to-line, as measured at the RT output into a pure resistive load of 70 ohm ±5 percent.

60.4.2.5.3.3 Output Noise. Any noise transmitted to the data bus when the RT is receiving or has power removed, shall not exceed a value of 14.0 millivolts RMS, line-to-line when measured at the point specified in 60.4.2.5.3.1.

60.4.2.5.4 RT Input Characteristics

60.4.2.5.4.1 Input Waveform Compatibility. The RT shall be capable of receiving and operating with the incoming signals specified herein, and shall accept waveforms varying from a square wave to a sine wave. The RT shall respond to an input signal whose positive or negative peak amplitude, line-to-line, is within the range of 10.0 to 0.5 volts. The voltages are measured at point C in Figure 7, MIL-STD-1553A.

60.4.2.5.4.2 Common Mode Rejections. Any signals from DC to 2.0 Mhz with amplitudes equal to or less than plus or minus 10.0 volts peak, line-to-ground, applied to point A as shown in Figure 7, MIL-STD-1553A, shall not degrade the performance of the RT.

60.4.2.5.4.3 Input Impedance. The magnitude of the RT input impedance, when the RT is not transmitting, or has power removed, shall be a minimum of 2000 ohms within the frequency range of 100 Khz to 1.0 Mhz. This impedance is that measured line-to-line at point C on Figure 7, MIL-STD-1553A.

60.4.2.5.4.4 Data Validation. Logic shall be provided in each RT to recognize improperly coded signals, data dropouts, or excessively noisy signals. Each word shall conform to the following minimum validating criteria:

a. The word begins with a valid sync field.

b. The bits are in a valid Manchester II code.

c. The information field has 16 bits plus parity.

d. The word parity is odd.

Where a word fails to conform to the preceding criteria, the word shall be considered invalid and shall not be used by the receiving RT. Where an invalid word sync occurs, the receiving RT shall reset and wait for a new valid message sync. An invalid word count shall be construed as a message transmission error. If the INS components receive an invalid command word, it shall not respond to that command. If the INS components receive a valid command, and invalid data word(s), the INS components shall reject the data words and indicate this fault in the status word.

60.4.3 Terminal Operation. The remote terminal shall operate in response to commands received from the bus controller. The RT shall be capable of receiving a command word at any time except when it is transmitting. A second command word sent to a terminal after it is already operating on one shall invalidate the first command and cause the RT to begin operation on the second command.

60.4.3.1 Response Time. The RT shall respond to a valid transmit data command during the time period 2.0 to 5.0 microseconds after receipt of the last bit of the command word. The RT shall respond to a valid receive data command during the time period 2.0 to 5.0 microseconds after receipt of the last bit of the last data word.

60.4.3.2 Terminal Fail-Safe Operation. The RT shall contain the self-test circuitry necessary to detect an erroneous transmission of data onto the data bus. This circuitry shall include a transmission time-out which will preclude a signal transmission period of greater than one status and thirty-two data words(0.66 to 0.89 milliseconds). When the self-test circuitry detects any such erroneous transmission, it shall automatically shut down the transmitter portion of the RT. The transmitter shut down shall be reset following receipt of a valid command word on the shut down bus.

60.4.3.3 Data Coherency/Sample Consistency. The INS shall maintain the time coherence of information transferred over the bus. It shall provide mutually consistent samples of information and deterministic transport lags. The INS design shall insure that messages transmitted over the bus contain only mutually consistent samples of information. Different words used to transmit multiple precision parameters shall all be members of the same set. Functionally related parameters updated at the same rate shall all be members of the same sample set. Suitable buffering and transmission control logic shall be provided to prevent the transmission of a partially updated message that would contain mutually inconsistent data. A 16 bit timer will be provided to time tag designated messages. The timer shall have a resolution of 64 microseconds per count and shall be capable of reset by a function word command. The only exception to these requirements are as noted in Table VI-2 and word formats in Table VI-8.

60.4.3.4 Noise Environment. The INS multiplex bus interfaces shall function as specified in Section 4.3.3 of MIL-STD-1553A.

60.4.4 Multiplex Hardware to INU or CDU Subsystem Interface. The INU and CDU will incorporate the multiplex hardware within their respective LRU's. Standard serial or parallel digital data buses to the SRU's are suggested.

60.4.5 Redundancy. Dual redundancy shall exist in (1) the transmission cables, and (2) the interface electronics.

60.4.5.1 Interface Electronics. Each INS component having an avionics serial digital data bus interface shall be capable of receiving command words over either of two buses and transmitting/receiving data over either bus. The INS component shall respond only to commands to transmit or receive data only over the bus on which a command is received. If the INS is transmitting or receiving data on one data bus and a valid transmit/receive command is received on the other bus, the INS shall terminate its communication on the first bus and respond to the command received on the second bus as specified in paragraphs 60.4.3 and 60.4.3.1. Command words transmitted over both buses will not overlap.

60.4.6 Bus Controller. The INU shall perform the function of Bus Controller when the double-ended bus control discrete is a logic 0 (see Table on Page 77), or if the discrete is left floating or if the driver is powered down. The INU shall relinquish control of the bus if the bus control discrete is a logic 1 (see Table on Page 77). The input circuits of the receiver shall present a minimum impedance of 10K Ω. Short circuit of the bus control discrete shall not damage the INU.

60.4.6.1 Two Bus Control System. The INU will function as a remote terminal when the bus control discrete is a logic 1 (2.4 VDC Min). When the primary bus controller is operational, it will raise the bus control discrete 20 ms before initiating activity. The INU should cease controller operation immediately upon detection of a high bus control discrete. After detecting the bus control discrete low for 20 ms, the INU should begin bus control operations.

60.4.6.2 Single Bus Control System. When the INS contains the only bus controller, the bus control discrete should be set low. This shall be accomplished in the vehicle wiring harness.

60.4.6.3 Bus Control Functions. The bus control functions are to supervise all serial digital data transmissions and to manage the data bus redundancy.

60.4.6.3.1 Transmission Supervision. The bus control function shall initiate all communication sequences by issuing command words over the data bus requesting subsystem to transmit or receive data. Refresh rate, message

block identification, subaddress fields and word counts required to generate the command words are contained in Table VI-2. The sequence of these commands shall be established by operational software in the INS. The bus control function shall also monitor each communication sequence and initiate corrective action for command words which are not properly executed. All refresh rates shall be construed to be minimum computation rates.

60.4.6.3.2 Redundancy Management. The bus controller shall manage the serial digital data bus redundancy. The error handling function of the INS bus controller shall monitor the bus transmissions, for the errors listed in 60.4.2.5.4.4. Errors detected during the transmission of a data block on one bus will cause a retry on the opposite bus for the next attempt to transmit data.

60.4.6.4 INU Command Table Requirements. When bus control is transfered to the INU, the INU shall perform the bus control function as follows:

a. If the INU terminal address as determined from the aircraft connector (in accordance with paragraph 60.4.2.3.5.1.2.1) is either 00100 or 00101, the INU shall operate as a controller according to the Unique CDU Interface Command Table VI-3. SAFE/MODE Commands will contain 11111 in the subadress/mode field.

b. If the INU terminal address as determined from the aircraft connector is any address other than 00100 or 00101, the INU shall operate as a controller according to the Generalized CDU Interface Command Table VI-3.

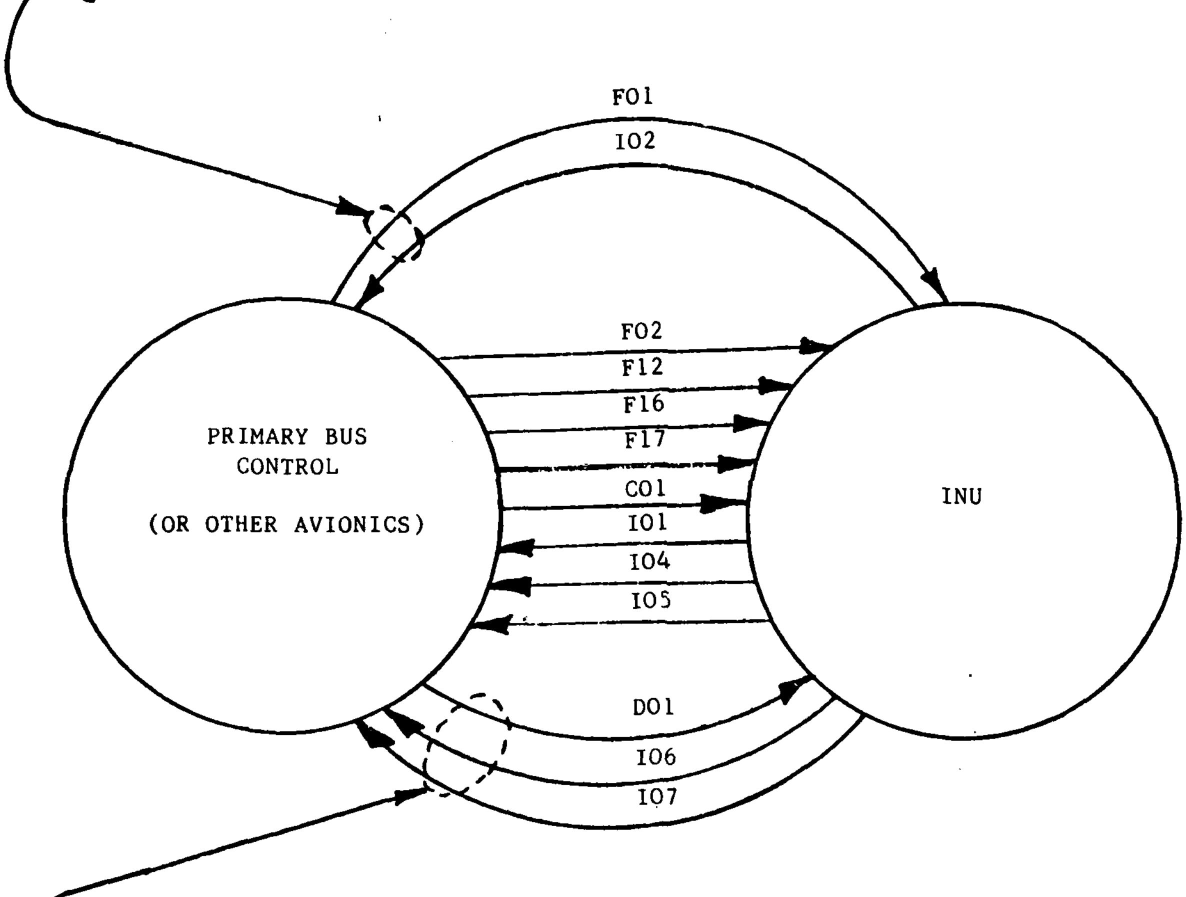
c. All Safe commands shown in Command Table VI-3 (i.e. SO2Safe, SO4Safe, etc.) are defined to be mode commands (dedicated function commands) which have a word count/mode of 01000. This code resets the receiver logic in the RT.

FIGURE VI-1

Typical Multiplex Data Bus Functional Diagram

(Under Primary Bus Control)

These message blocks (Group A) used with a unique CDU panel mechanization which is dependent on INU software.



These message blocks (Group B) used with a generalized CDU panel mechanization which is independent of INU software.

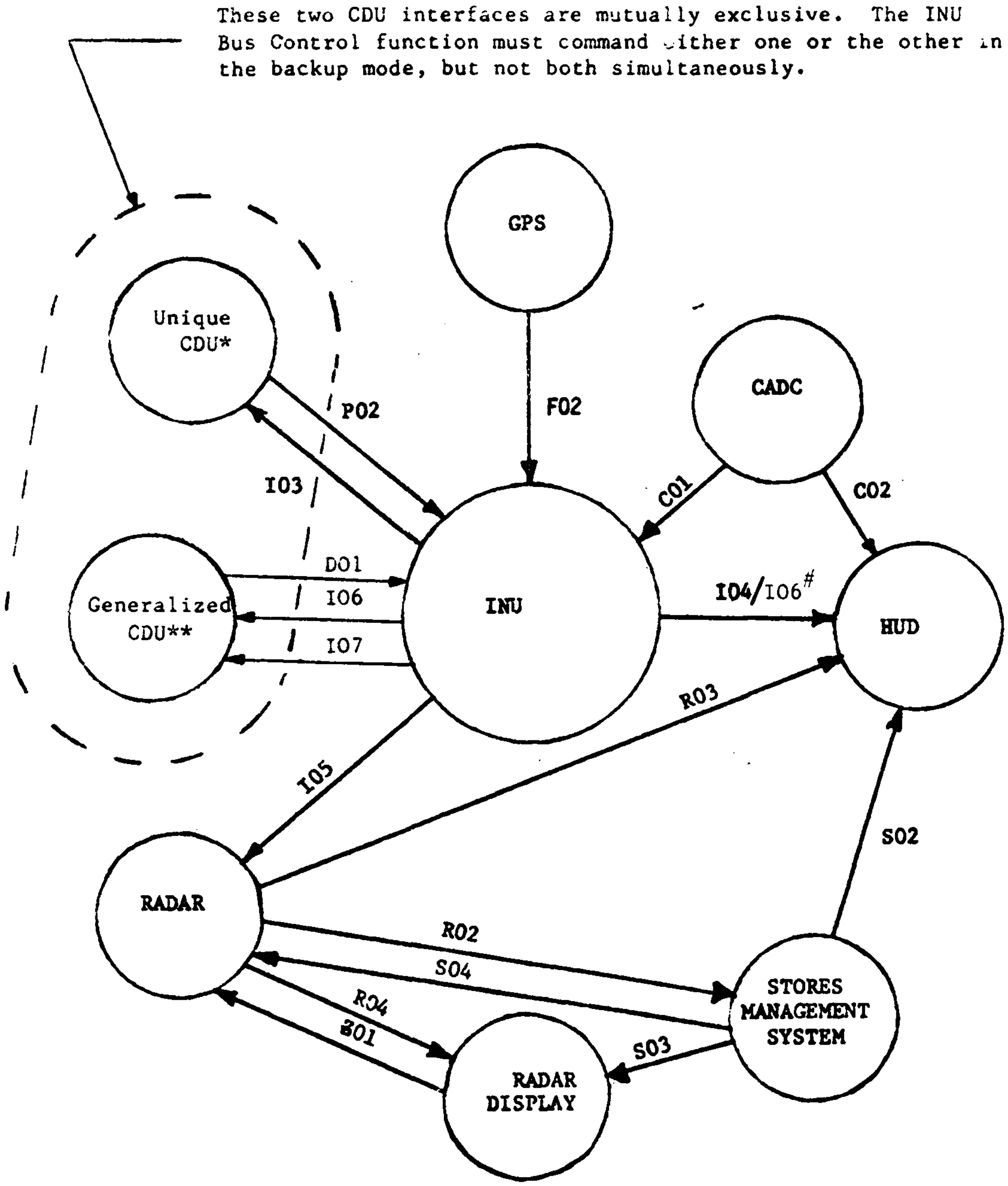
Groups A and B are mutually exclusive to any typical system.

Message blocks shown defines INU transmit/receive requirements when operating as a remote terminal.

FIGURE VI-2

Multiplex Data Bus Functional Block Diagram

(Under INU Bus Control)



* Dependent on INU software.
** Independent of INU software.

{I04 with Unique CDU interface.
I06 with Generalized CDU interface.}

TABLE VI-1

BACK-UP CONTROL FUNCTION

AVIONIC SUBSYSTEM TERMINAL ADDRESSES

Terminal Address	Subsystem
01000	Control Display (Unique)
01100	HUD
10000	Radar Display
10100	Radar
10110	Generalized CDU
11000	Stores Management System
11010	Global Positioning System
11100	CADC
11111	Prohibited Address

NOTE: All other terminal addresses shall be defined by the aircraft system integrator. All five bits of the terminal address field shall be connector programmable. The INU terminal address when interfaced with the Unique CDU shall be either 00100 or 00101. The INU terminal address when interfaced with the Generalized CDU shall not be any of the above listed addresses (including 00100 and 00101).

TABLE VI-2

Subsystem Subaddress/Word Count/Rates

Transmit Subsystem	Block ID	Subaddress	Word Count	(Times per second) Refresh Rate*	Transmit Rate*
INU	I01	10000	28	50	50
	I02	10001	10	5.0	6.25
	I03	10001	8	5.0	6.25
	I04	10000	13	50	50
	I05	10000	13	50	50
	I06	11001	31	**	50
	I07	11011	32	2.5	6.25
CDU	P02	10000	4	5.0	6.25
	D01	11010	7	5.0	6.25
CADC	C01	10000	10	25	25
	C02	10000	9	25	25
	C03	10000	2	25	25
Radar Display	Z01	10001	1	6.25	6.25
Radar	R02	10001	3	50	50
	R03	10000	5	50	50
	R04	10010	9	25	25
Stores Management System	S02	10000	4	50	50
	S03	10000	2	1.5625	1.5625
	S04	10000	4	50	50
GPS	F02	10001	16	50	50

* All rates are minimum.

** Refresh Rates as specified in Table VI-8 Word Formats.

TABLE VI-2 Continued

Subsystem Subaddress/Word Count Rates

Receive Subsystem	Block ID	Subaddress	Word Count	(Times per Second) Refresh Rate*	Transmit Rate*
INU	C01	11110	10	25	25
	C03	10011	2	25	25
	F01	10100	7	12.5	12.5
	F02	10001	16	50	50
	F12	10110	25	1.5625	1.5625
	F16	10101	29	1.5625	1.5625
	F17	10010	2	As Required	As Required
	P02	10100	4	5.0	6.25
	D01	11010	7	5.0	6.25
CDU	I03	10000	8	5.0	6.25
	I06	11001	31	**	50
	I07	11011	32	2.5	6.25
Radar Display	R04	10100	9	25	25
	S03	10011	2	1.5625	1.5625
Radar	Z01	10011	1	6.25	6.25
	S04	10010	4	50	50
	I05	10001	13	50	50
HUD	I04	11010	13	50	50
	R03	11011	5	50	50
	S02	11100	4	50	50
	C02	11101	9	25	25
Stores Management	R02	10001	3	50	50

* All rates are minimum.

** Refresh rates as specified in Table VI-8 Word Formats.

TABLE VI-3

UNIQUE CDU INTERFACE
BACK-UP BUS CONTROLLER COMMAND TABLE

MS	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320
FRAMES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04
	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05
	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02
	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE
	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04
	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE
	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02
	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE
	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03
	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE
		C02	I03	C02	Z01	C02		C02		C02	I03	C02	Z01	C02		C02
		C02SAFE	P02	C02SAFE	Z01SAFE	C02SAFE		C02SAFE		C02SAFE	P02	C02SAFE	Z01SAFE	C02SAFE		C02SAFE
		C01		C01		C01		C01		C01		C01		C01		C01
		R04		R04		R04		R04		R04		R04		R04		R04
		R04SAFE		R04SAFE		R04SAFE		R04SAFE		R04SAFE		R04SAFE		R04SAFE		R04SAFE

MS	340	360	380	400	420	440	460	480	500	520	540	560	580	600	620	640
FRAMES	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04	I04
	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05
	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02
	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE	S02SAFE
	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04
	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE	S04SAFE
	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02
	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE	R02SAFE
	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03
	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE	R03SAFE
	S03	C02	I03	C02	Z01	C02		C02		C02	I03	C02	Z01	C02		C02
	S03SAFE	C02SAFE	P02	C02SAFE	Z01SAFE	C02SAFE		C02SAFE		C02SAFE	P02	C02SAFE	Z01SAFE	C02SAFE		C02SAFE
		C01		C01		C01		C01		C01		C01		C01		C01
		R04		R04		R04		R04		R04		R04		R04		R04
		R04SAFE		R04SAFE		R04SAFE		R04SAFE		R04SAFE		R04SAFE		R04SAFE		R04SAFE

NOTE: SAFE COMMANDS ARE MODE COMMANDS.

TABLE VI-3 (CONTINUED)

GENERALIZED CDU INTERFACE
BACK-UP BUS CONTROLLER COMMAND TABLE

MS	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320
FRAMES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06
	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05
	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02
	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02
	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04
	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02
	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03
		C02	I06	C02	Z01	C02		C02		C02	I06	C02	Z01	C02		C02
		C01	I07	C01		C01		C01		C01	I07	C01		C01		C01
		R04	D01	R04		R04		R04		R04	D01	R04		R04		R04

MS	340	360	380	400	420	440	460	480	500	520	540	560	580	600	620	640
FRAMES	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06	I06
	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05	I05
	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02	F02
	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02	S02
	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04	S04
	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02	R02
	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03	R03
	S03	C02	I06	C02	Z01	C02		C02		C02	I06	C02	Z01	C02		C02
		C01	I07	C01		C01		C01		C01	I07	C01		C01		C01
		R04	D01	R04		R04		R04		R04	D01	R04		R04		R04

TABLE VI-4

SUMMARY OF I06 and I07 OUTPUTS

I06-01	INU Control Word 1
I06-02	Time Tag - Referenced to the beginning of the velocity computation cycle.
I06-03 thru I06-08	Velocity X,Y,Z - Velocity components referenced to the platform axis.
I06-09	Platform Azimuth - Clockwise angle from the platform X axis to the vehicle mounting pads.
I06-10	Roll } Referenced to local earth level.
I06-11	Pitch } Referenced to local earth level.
I06-12	Present True Heading
I06-13	Present Magnetic Heading
I06-14	Great Circle Steering Error - Defined as a function of Steering Mode: Great Circle Steering - Bit 15 of D01-02 set to Logic "0" See θ_{SE} Figure B Selected Course Steering - Bit 15 of D01-02 set to Logic "1" θ_{SE} is defined to be zero
I06-15	Computed Course Deviation - Defined as a function of Steering Mode: Great Circle Steering - Bit 15 of D01-02 set to Logic "0" See θ_{CD} Figure B Selected Course Steering - Bit 15 of D01-02 set to Logic "1" θ_{CD} =-(Magnetic bearing to position where bit 15 was set to Logic "1") $\pm$ (180°) + (Selected Magnetic Course)
I06-16	Time to Steerpoint - Predicted time based on groundspeed computed from using last computed wind assuming that present true air speed shall remain constant.
I06-17	Distance to Steerpoint
I06-18	Relative Bearing to Steerpoint = (True Bearing) - (True Heading)
I06-19	Relative Bearing to nth Waypoint/Markpoint = (True Bearing) - (True Heading)
I06-20	Time to nth Waypoint/Markpoint - Predicted time based on groundspeed computed from using last computed wind assuming that present true air speed shall remain constant.
I06-21	Distance to nth Waypoint/Markpoint.
I06-22	INU Control Word 3
I06-23	nth Waypoint/Markpoint Latitude (Most Significant Part)
I06-24	nth Waypoint/Markpoint Latitude (Least Significant Part)
I06-25	nth Waypoint/Markpoint Longitude (Most Significant Part)
I06-26	nth Waypoint/Markpoint Longitude (Least Significant Part)
I06-27	Selected Magnetic Course to Steerpoint - Desired magnetic ground track to steerpoint (Used with Great Circle Steering).
I06-28	Selected Magnetic Course - Desired magnetic ground track from point where Selected Course Steering was selected.
I06-29	Magnetic Heading to nth Waypoint/Markpoint - Magnetic course to selected position corrected for Drift Angle as computed using last computed wind assuming that present true air speed shall remain constant.
I06-30	True Air Speed - Last true air speed received from the CADC.
I06-31	Present Magnetic Ground Track.

TABLE VI-4 Cont'd

I07-01	nth Waypoint/Markpoint Spheroid/UTM Grid Zone (MSP)
I07-02	nth Waypoint/Markpoint UTM Grid Zone (LSP)
I07-03	nth Waypoint/Markpoint UTM 100,000 Meter Zone
I07-04	nth Waypoint/Markpoint UTM Easting
I07-05	nth Waypoint/Markpoint UTM Northing
* I07-06	Present Position Latitude (MSP)
* I07-07	Present Position Latitude (LSP)
* I07-08	Present Position Longitude (MSP)
* I07-09	Present Position Longitude (LSP)
* I07-10	Present Position Spheroid/UTM Grid Zone (MSP)
* I07-11	Present Position UTM Grid Zone (LSP)
* I07-12	Present Position UTM 100,000 Meter Zone
* I07-13	Present Position UTM Easting
* I07-14	Present Position UTM Northing
I07-15	Entered True Heading
I07-16	Entered Magnetic Heading
I07-17	Entered Magnetic Variation
I07-18	Computed Magnetic Variation
I07-19	Align Time and Status
I07-20	Wind Direction - The direction from which the wind blows, i.e. 180° plus the angle measured clockwise from True North to the head of the wind vector.
I07-21	Wind Velocity/Last Mark Point Code
I07-22	Present Ground Speed
I07-23	Present True Ground Track
I07-24	Predicted Ground Speed - Computed from last computed wind assuming that present True Airspeed shall remain constant.
I07-25	Present Convergence Factor in Use (Grid Mode)
I07-26	Present Grid Heading - Vehicle Heading referenced to Grid North.
I07-27	Desired Grid Heading - Desired Grid Course corrected for Drift Angle as computed using last computed wind assuming that present true air speed shall remain constant.
I07-28	Position Error North (AUXILIARY and OVERFLY update modes)
I07-29	Position Error East (AUXILIARY and OVERFLY update modes)
I07-30 thru I07-32	INU Miscellaneous Data

* NOTE: "Inertial Display" position information.

TABLE VI-5
PREDICTED SITUATION OUTPUT DATA

Block/Word Ident	Descriptive Name	INU Modes: OFF	Stored Heading Align	Gyrocompass Align	Air Align	Navigate	Overfly Fix	Auxiliary Fix	Calibrate	Attitude	Test
I06-20	Time to nth Waypoint/Markpoint	X	X	X					X	X	X
I06-16	Time to Steerpoint	X	X	X					X	X	X
I06-29	Magnetic Heading to nth Waypoint/Markpoint	X	X	X					X	X	X
I07-24	Predicted Ground Speed	X	X	X					X	X	X
I07-27	Desired Grid Heading to Steerpoint	X	X	X					X	X	X

NOTE: INU Modes marked with an X indicate that the indicated I06 and/or I07 words shall contain all Logic "0's" in the indicated INU Mode.

TABLE VI-6

CURRENT SITUATION OUTPUT DATA

Block/Word Ident	Descriptive Name	INU MODES: OFF	Stored Heading Align	Gyrocompass Align	Air Align	Navigate	Overfly Fix	Auxiliary Fix	Calibrate	Attitude	Test
I06-03 thru I06-08	Velocity X, Y & Z	X								X	
I06-09	Platform Azimuth	X									
I06-10	Roll	X									
I06-11	Pitch	X									
I06-12	Present True Heading	X	X	X					X	X	X
I06-13	Present Magnetic Heading	X	X	X					X	X	X
I06-14	Great Circule Steering Error	X	X	X					X	X	X
I06-15	Computed Course Deviation	X	X	X					X	X	X
I06-19	Relative Bearing to nth Waypoint/Markpoint	X	X	X					X	X	X
I06-21	Distance to nth Waypoint/Markpoint	X	X	X					X	X	X
I06-17	Distance to Steerpoint	X	X	X					X	X	X
I06-18	Relative Bearing to Steerpoint	X	X	X					X	X	X
I06-30	True Air Speed (From CADC)	X	X	X					X	X	X
I06-31	Present Magnetic Ground Track	X	X	X					X	X	X
I07-18	Computed Magnetic Variation	X							X		
I07-19	Align Time and Status	X							X		
I07-20	Wind Direction	X	X	X					X	X	X
I07-21	Wind Velocity/Last Mark Point Code	X	X	X					X	X	X
I07-22	Present Ground Speed	X	X	X					X	X	X
I07-23	Present True Ground Track	X	X	X					X	X	X
I07-25	Present Convergence Factor in Use	X								X	
I07-26	Present Grid Heading	X	X	X					X	X	X
I07-28	Position Error North	X	X	X					X	X	X
I07-29	Position Error East	X	X	X					X	X	X
I07-06 thru I07-09	Present Position Latitude & Longitude	X									
I07-10 thru I07-14	Present Position UTM and Spheriod	X									

NOTE: INU Modes marked with an X indicate that the indicated I06 and/or I07 words shall contain all Logic "0's" in the indicated INU Mode.

TABLE VI-7

INU OUTPUTS OF INSERTED DATA

Block/Word Ident	D01** Codes	Descriptive Name	INU Modes: OFF	Stored Heading Align	Gyrocompass Align	Air Align	Navigate	Overfly Fix	Auxiliary Fix	Calibrate	Attitude	Test
I07-06 thru I07-09	00000	Present Position Latitude & Longitude	X									
I07-10 thru I07-14	00001	Present Position UTM and Spheroid	X									
I07-15	00010	True Heading (BATH Entry)	X									
I07-17	00011	Magnetic Variation	X									
I06-27	00100	Selected Magnetic Course to Steerpoint	X									
I06-23 thru I06-26*	00101	Waypoint/Markpoint Latitude & Longitude	X									
I07-01 thru I07-05*	00110	Waypoint/Markpoint UTM and Spheroid	X									
I07-25 (Factor in Use)	00111	Convergence Factor	X									
I07-30 thru I07-32	01000	Misc. Parameter Read	X									
I07-30 thru I07-32	01001	Misc. Parameter Insert	X									
I07-16	01010	Magnetic Heading (BATH Entry)	X									
I06-28	01011	Selected Magnetic Course	X									

NOTE: INU Modes marked with an X indicate that the indicated I06 and/or I07 word(s) shall contain all Logic "0's" in the indicated INU Mode.

* The nth Waypoint/Markpoint is defined by bits 7 thru 10 of D01-01.

** See Control Word D01-02.

TABLE VI-8

INS MESSAGE WORD/BIT FORMAT

1. Generalized CDU to INU

SUBADDRESS: D01

WORD #1 - CDU Control Word 1

SUBADRESS: D01-01 Refresh Rate = 5.0/sec. Transmission Rate = 6.25/sec.

DATA BIT	DESCRIPTION
1	CDU Fault Flag (See Note 3)
2	MSB
3	*
4	** Function Select Code (See Note 1)
5	*
6	LSB
7	MSB
8	** Waypoint/Markpoint Select (See Note 2)
9	*
10	LSB
11	Steerpoint Select Bit (See Note 3)
12	D01 Message Invalid
13	Logic "o"
14	Logic "o"
15	Logic "o"
16	Logic "o"

Note 1: Function Select Codes

CODE	FUNCTION
00000	Off
00001	Stored Heading Align
00010	G/C Align
00011	Air Align
00100	Navigate
00101	Overfly Fix
00110	Auxiliary Fix
00111	Calibrate
01000	Attitude
01001	Test
01010 thru 11111	Reserved Codes

Note 3: A logic 1 shall indicate that the waypoint/markpoint identified by bits 7 thru 10 is the selected steerpoint. This bit will be held at logic 1 until I06-22 bits 6 thru 9 agree with the selected steerpoint.

Note 2: Waypoint/Markpoint Select Codes

0000	Waypoint 0	1010	First Markpoint
thru	thru	thru	thru
1001	Waypoint 9	1111	Sixth Markpoint

WORD #2 - CDU Control Word 2

SUBADDRESS: D01-02 Refresh Rate = 5.0/sec. Transmission Rate = 6.25/sec.

DATA BIT	DESCRIPTION	
1	Fix Freeze Flag	
2	Fix Enter Flag	
3	Mark Flag	(See Note 1)
4	Clear Flag	
5	Data Ready Flag	(See Note 2)
6	MSB	
7	*	
8	**Inserted Data ID Code (See Note 3)	
9	*	
10	LSB	
11	Manual/Automatic Update (See Note 4)	
12	Mag Var Flag	
13	Digital Select Flag	
14	Grid Mode Flag	
15	Steering Mode Code (See Note 5)	
16	Logic "0"	

Note 1: This D01-02 bit shall be set to Logic 1 when the indicated INU operation is to be activated. When this D01-02 flag bit is set, the INU shall respond with a Logic 1 set in the corresponding bit of the I06-22 word. Subsequent to receipt of the set I06-22 bit, the corresponding D01-02 bit shall be reset to Logic 0. Subsequent to the D01-02 bit reset, the corresponding I06-22 bit shall be reset.

Note 2: This bit is set when new data is to be inserted into the INU, and the appropriate code has been defined for bits 6 thru 10 of D01-02 (i.e. Misc Parameter Read/Insert Code 01000/01001 in bits 6 thru 10 and Misc Parameter Code in the D01-03 word). This bit shall be reset as specified in Note 1 for D01-02.

Note 3: Inserted Data ID Codes

00000	Present Position in Lat./Long.
00001	Present Position in UTM (plus spheroid)
00010	True Heading (Bath Entry)
00011	Magnetic Variation
00100	Selected Magnetic Course to Steerpoint
00101	Waypoint/Markpoint in Lat./Long.
00110	Waypoint/Markpoint in UTM (plus spheroid)
00111	Convergence Factor
01000	Misc. Parameter Read
01001	Misc. Parameter Insert
01010	Magnetic Heading (Bath Entry)
01011	Selected Magnetic Course
01100 thru 11111	Reserved Codes

NOTE 4. This bit is used in conjunction with the Automatic, Semi-Automatic and Manual update modes. Automatic updates supercede and cancel any pending Semi-Automatic or Manual updates. The Semi-Automatic and Manual update modes are mutually exclusive. The Semi-Automatic mode is active upon receipt of an F02 Correction Vector, and the Manual mode is active upon receipt of either

SUBADDRESS: D01-02 Cont'd

the FIX FREEZE (D01-02 bit 1 1) or DESIGNATE discrete while the applicable Function Select Code is set. Once activated, the Semi-Automatic and Manual modes remain pending, if the mode is exited without an accept or reject decision, provided that an Automatic update is not received. The mode must be re-entered in order to accept or reject a pending update that was exited prior to accept/reject decision. Receipt of update commands while any update mode is pending shall always terminate the pending update and activate a new update.

a. Automatic - When operative, this mode updates the INU from the F02 Correction Vector message without intervention from the operator. The related bit logic is:

(1) D01-01 bits 2 thru 6 - set to Air Align logic code 00011

(2) F02-01 bit 2 - set to logic 1

(3) D01-02 bit 11 - set to logic 1

(4) D01-02 bits 1, 2 & 4 - set to logic Ø

b. Semi-Automatic - When operative, this mode provides for automatic input of update data from the F02 Correction Vector message with operator intervention required to either accept or reject the update. Position data only shall be used in this update mode regardless of whether other data is contained in the F02 message. The related bit logic is:

(1) D01-01 bits 2 thru 6 - set to Auxiliary Fix logic code 00110

(2) F02-01 bit 2 - set to logic 1

(3) D01-02 bit 11 - set to logic Ø

(4) D01-02 bit 1 - set logic Ø

(5) D01-02 bit 2 - set to logic 1 if update is desired

(6) D01-02 bit 4 - set to logic 1 if update is not desired

c. Manual - This mode is used to update the INU by overflying a known position which has been inserted via the CDU or an external computer. Operator intervention via the CDU shall be required to either accept or reject the update. The related bit logic is:

(1) D01-01 bits 2 thru 6 - set to Overfly Fix logic code 00101

(2) D01-02 bit 11 - set to logic Ø

(3) D01-02 bit 1 - set to logic 1

(4) D01-02 bit 2 - set to logic 1 if update is desired

(5) D01-02 bit 4 - set to logic 1 if update is not desired

NOTE 5. Logic "0" for Great Circle Steering Mode. Logic "1" for Selected Course Steering.

WORDS #3, 4, 5, 6, 7 - CDU Inserted Data Words

SUBADDRESS: D01-03, D01-04, D01-05, D01-06, D01-07

Refresh Rate = 5.0/sec. Transmission Rate = 6.25/sec.

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	* (See Note 1)
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

Note 1: The format for each of the five data words shall be defined by the Inserted Data ID Code in bits 6 thru 10 of word D01-02. For quantities which do not require all five words to express their values, the unused words shall be sent as all logic "0". Table VI-8A indicates which words are unused for a given quantity.

TABLE VI-8A D01 WORD USAGE

CODE	INSERTED DATA	FORMAT	WORD CONTENTS D01-03	D01-04	D01-05	D01-06	D01-07
00000	PRESENT POSITION (L/L)	I	Q	Q	Q	Q	X
00001	PRESENT POSITION (UTM) & SPHEROID	II	Q	Q	Q	Q	Q
00010	TRUE HEADING (BATH ENTRY)	III	Q	X	X	X	X
00011	MAGNETIC VARIATION	IV	Q	X	X	X	X
00100	SELECTED MAG COURSE TO STEERPOINT	V	Q	X	X	X	X
00101	WAYPOINT/MARKPOINT (L/L)	VI	Q	Q	Q	Q	X
00110	WAYPOINT/MARKPOINT (UTM) & SPHEROID	VII	Q	Q	Q	Q	Q
00111	CONVERGENCE FACTOR	VIII	Q	X	X	X	X
01000	MISC. PARAMETER READ	IX	Q	X	X	X	X
01001	MISC. PARAMETER INSERT	X	Q	Q	Q	Q	X
01010	MAGNETIC HEADING (BATH ENTRY)	XI	Q	X	X	X	X
01011	SELECTED MAGNETIC COURSE	XII	Q	X	X	X	X
01100 thru 11111	RESERVED CODES						

NOTE: The presence of a "Q" on the table indicates that the word is used to represent a quantity for a given Inserted Data Code. If the word is not used, indicated by an "X", it shall be transmitted as all logic zero's.

FORMAT I

WORD FORMATS FOR DATA ID CODES

Data ID Code: 00000 (See D01-02)

INSERTED PRESENT POSITION LATITUDE/LONGITUDE

WORD #3 - Latitude (MSP)

Subaddress: D01-03

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5 π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #4 - Latitude (LSP)

Subaddress: D01-04

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

REMARKS: MSP=Most significant part
LSP=Least significant part

FORMAT I (cont'd)

Data ID Code: 00000 (See D01-02)

INSERTED PRESENT POSITION LATITUDE/LONGITUDE

WORD #5 - Longitude (MSP)

Subaddress: D01-05

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5 π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #6 - Longitude (LSP)

Subaddress: D01-06

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

FORMAT II

Data ID Code: 00001 (See D01-02)

INSERTED POSITION UTM & SPHEROID

WORD #3 - Spheroid/Grid Zone

Subaddress: D01-03

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	*
5	** ASCII Code for
6	**Spheroid Mod. (See Note 1)
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	** UTM Grid Zone (MSC)
13	** in ASCII (See Note 2&4)
14	*
15	*
16	LSB

WORD #4 - Grid Zone

Subaddress: D01-04

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	** UTM Grid Zone
5	** in ASCII
6	*
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	** UTM Grid Zone (LSC)
13	** in ASCII
14	* (See Note 3)
15	*
16	LSB

Note 1: The code for spheroid model shall be as follows:

Model	ASCII Code	Binary Value
International	0	0110000
Clark 1866	1	0110001
Clark 1880	2	0110010
Everest	3	0110011
Bessel	4	0110100
Australian National	5	0110101
Airy	6	0110110
Hough	7	0110111
South American	8	0111000
Modified Everest	9	0111001
WGS-72	A	1000001

Note 2: MSC = Most significant character

Note 3: LSC = Least significant character

Note 4: The order of the characters designating the UTM Grid Zone is column first and then row.

FORMAT II (cont'd)

Data ID Code: 00001 (See D01-02)

INSERTED POSITION UTM & SPHEROID

WORD #5 - 100,000 Meter Grid Zone

Subaddress: D01-05

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	*
5	** UTM Area (MSC)
6	** in ASCII
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	*
13	** UTM Area (LSC)
14	** in ASCII (See Note 2)
15	*
16	LSB

WORD #6 - Easting

Subaddress: D01-06

DATA BIT	DESCRIPTION
1	MSB (65,536 meters)
2	*
3	*
4	*
5	*
6	*
7	*
8	** UTM Easting
9	** (See Note 1)
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (2 meters)

WORD #7 - Northing

Subaddress: D01-07

DATA BIT	DESCRIPTION
1	MSB (65,536 meters)
2	*
3	*
4	*
5	*
6	*
7	*
8	** UTM Northing
9	** (See Note 1)
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (2 meters)

Note 1: Maximum value shall not exceed 99,998.0 meters.

Note 2: The order of the characters designating the 100,000 Meter Grid Zone is column first and then row.

FORMAT III

Data ID Code: 00010 (See D01-02)

INSERTED TRUE HEADING (BATH ENTRY)

WORD #3 - True Heading

Subaddress: D01-03

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

FORMAT IV

Data ID Code: 00011 (See D01-02)

INSERTED MAGNETIC VARIATION

WORD #3 - Magnetic Variation

Subaddress: D01-03

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

FORMAT V

Data ID Code: 00100 (See D01-02)

INSERTED SELECTED MAGNETIC COURSE TO STEERPOINT

WORD #3 - Magnetic Course to Steerpoint

Subaddress: D01-03

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

FORMAT VI

Data ID Code: 00101 (See D01-02)

INSERTED WAYPOINT/MARKPOINT LATITUDE/LONGITUDE

WORD #3 - Latitude (MSP)

Subaddress: D01-03

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #4 - Latitude (LSP)

Subaddress: D01-04

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

REMARKS: MSP=Most significant part
LSP=Least significant part

FORMAT VI (cont'd)

Data ID Code: 00101 (See D01-02)

INSERTED WAYPOINT/MARKPOINT LATITUDE/LONGITUDE

WORD #5 - Longitude (MSP)

Subaddress: D01-05

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #6 - Longitude (LSP)

Subaddress: D01-06

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

FORMAT VII

Data ID Code: 00110 (See D01-02)

INSERTED WAYPOINT/MARKPOINT UTM & SPHEROID

WORD #3 - Spheroid/Grid Zone

Subaddress: D01-03

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	** ASCII Code for
5	** Spheroid Model (See Note 1)
6	*
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	** UTM Grid Zone (MSC)
13	** in ASCII (See Note 2 & 4)
14	*
15	*
16	LSB

WORD #4 - Grid Zone

Subaddress: D01-04

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	** UTM Grid Zone
5	** in ASCII
6	*
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	**UTM Grid Zone(LSC)
13	** in ASCII (Note 3)
14	*
15	*
16	LSB

Note 1: The code for spheroid models are as follows:

Model	ASCII Code	Binary Value
International	0	0110000
Clark 1866	1	0110001
Clark 1880	2	0110010
Everest	3	0110011
Bessel	4	0110100
Australian National	5	0110101
Airy	6	0110110
Hough	7	0110111
South American	8	0111000
Modified Everest	9	0111001
WGS-72	A	1000001

Note 2: MSC = Most significant character

Note 3: LSC = Least significant character

Note 4: The order of the characters designating the UTM Grid Zone is column first and then row.

FORMAT VII (cont'd)

Data ID Code: 00110 (See D01-02)

INSERTED WAYPOINT/MARKPOINT UTM & SPHEROID

WORD #5 - 100,000 Meter Grid Zone

Subaddress: D01-05

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	*
5	** UTM Area (MSC)
6	*
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	*
13	** UTM Area (LSC)
14	* in ASCII (See Note 2)
15	*
16	LSB

WORD #6 - Easting

Subaddress: D01-06

DATA BIT	DESCRIPTION
1	MSB (65,536 meters)
2	*
3	*
4	*
5	*
6	*
7	*
8	** UTM Easting
9	** (See Note 1)
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (2 meters)

WORD #7 - Northing

Subaddress: D01-07

DATA BIT	DESCRIPTION
1	MSB (65,536 meters)
2	*
3	*
4	*
5	*
6	*
7	*
8	** UTM Northing
9	** (See Note 1)
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (2 meters)

Note 1: Maximum value shall not exceed 99,998.0 meters.

Note 2: The order of the characters designating the 100,000 Meter Grid Zone is column first and then row.

FORMAT VIII

Data ID Code: 00111 (See D01-02)

INSERTED CONVERGENCE FACTOR

WORD #3 - Convergence

Subaddress: D01-03

DATA BIT	DESCRIPTION
1	MSB (1.0)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

FORMAT IX

Data ID Code: 01000 (See D01-02)

MISC PARAMETER READ

WORD #3 - Misc. Parameter Code

Subaddress: D01-03

DATA BIT	DESCRIPTION
1	MSB
2	*
3	*
4	*
5	*
6	*
7	*
8	*** (See Note 1)
9	***
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

Note 1: A specific binary integer code shall be assigned for each miscellaneous parameter:

Decimal Equivalent of Binary Code	
0	Manufacturer's Identification Code
1	Bite Summary 1
2	Bite Summary 2
3	Initialization Latitude
4	Initialization Longitude
5	Present "pure inertial" Latitude
6	Present "pure inertial" Longitude
7 thru 100	Aircraft peculiar functions TBD.

All remaining codes - Contractor peculiar functions TBD.

FORMAT X

Data ID Code: 01001 (See D01-02)

MISC PARAMETER INSERT

WORD #3 - Misc. Parameter Code

Subaddress: D01-03

DATA BIT	DESCRIPTION
1	MSB
2	*
3	*
4	*
5	*
6	*
7	*
8	** T.B.D. Binary Code
9	* (See Note 1)
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #4 - Parameter Word 1

Subaddress: D01-04

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB
3	*
4	*
5	** ASCII Parameter (MSC)
6	* (See Note 2)
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	*
13	** ASCII Parameter
14	** (See Note 2)
15	*
16	LSB

Note 1: A specific binary integer code shall be assigned for each miscellaneous parameter.

Decimal Equivalent of Binary Code	
0 thru 6	- Shall not be used.
7 thru 100	- Aircraft peculiar functions TBD.
All remaining codes	- contractor peculiar functions TBD.

Note 2: Non-printing and lower case characters shall not be used.

FORMAT X (cont'd)

Data ID Code: 01001 (See D01-02)

MISC PARAMETER INSERT

WORD #5 - Parameter Word 2

Subaddress: D01-05

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	*
5	** ASCII Parameter
6	** (See Note 1)
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	8
13	** ASCII Parameter
14	** (See Note 1)
15	*
16	LSB

WORD #6 - Parameter Word 3

Subaddress: D01-06

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	*
5	** ASCII Parameter
6	** (See Note 1)
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	*
13	** ASCII Parameter
14	** (LSC)
15	* (See Note 1)
16	LSB

Note 1: Non-printing and lower case characters shall not be used.

FORMAT XI

Data ID Code: 01010 (See D01-02)

INSERTED MAGNETIC HEADING (BATH ENTRY)

WORD #3 - MAGNETIC HEADING

Subadress: D01-03

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

FORMAT XII

Data ID Code: 01011 (See D01-02)

INSERTED SELECTED MAGNETIC COURSE

WORD #3 - SELECTED MAGNETIC COURSE

Subadress: D01-03

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5 π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

II. INU to HSI/HUD/Displays

SUBADDRESS: I06

WORD #1 - INU Control Word 1

SUBADDRESS: I06-01 Refresh & Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Att Ref Fail (Note 1)
2	Navigation Fail (Note 2)
3	Degraded Navigation
4	Navigation Data Unavailable (Note 3)
5	Dig Att Data Invalid (Note 4)
6	In Fine Align (Note 5)
7	In Coarse Align (Note 6)
8	Control Vector Acknowledge
9	Altitude Loop Bit (Note 7)
10	INU in Self-test
11	Pole Flag
12	In Manual Mag Variation
13	Digital Select
14	In Grid Mode
15	CDU Fail
16	NAV Ready (Note 8)

REMARKS: A Logic 1 shall indicate that the referenced condition is true.

NOTE 1: The platform has failed and no navigation or attitude data is available.

NOTE 2: The INU computer has failed. Attitude outputs are still valid (gimballed systems).

NOTE 3: The INU is not in the Nav mode. Position and velocity data are not being calculated.

NOTE 4: Is invalid due to A/D converter or platform failure.

NOTE 5: Nav mode may be entered. Att and Hdg data are valid.

NOTE 6: Att data is available and attitude mode is not true. Hdg data is not avaiable. Nav mode may not be entered.

NOTE 7: Baro-Inertial Altitude data is invalid.

NOTE 8: Nav mode may be entered with full specified performance.

WORD # 2 - INU Control Word 2

SUBADDRESS: I06- 02 Refresh & Transmission Rate = 50/sec.

Signal Name - Time Tag

DATA BIT	DESCRIPTION
1	MSB (2,097,152 Microsec)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (64 Microsec)

WORD #3 - Velocity X (MSP)

SUBADDRESS: I06-03

Refresh & Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #4 - Velocity X (LSP)

SUBADDRESS: I06-04

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #5 - Velocity Y (MSP)

SUBADDRESS: I06-05

Refresh & Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #6 - Velocity Y (LSP)

SUBADDRESS: I06-06

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #7 - Velocity Z (MSP)

SUBADDRESS: I06-07

WORD #8 - Velocity Z (LSP)

SUBADDRESS: I06-08

Refresh & Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #9 - Platform Azimuth

SUBADDRESS: I06-09 Refresh & Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

REMARKS:

ACCURACY: 0.00175 radians RMS angle error between X axis and INU boresight.

WORD #10 - Roll

SUBADDRESS: I06-10 Refresh & Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

REMARKS:

ACCURACY: 0.00175 radians RMS.

WORD #11 - Pitch

SUBADDRESS: I06-11 Refresh & Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5 π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

REMARKS:

ACCURACY: 0.00175 radians RMS.

WORD #12 - Present True Heading

SUBADDRESS: IO6-12 Refresh Rate = 10/sec. Transmit Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5 π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

REMARKS:

ACCURACY: 0.00175 radians RMS.

WORD #13- Present Magnetic Heading

SUBADDRESS: I06-13 Refresh Rate = 10/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

REMARKS:

ACCURACY: 0.0035 radians RMS.

WORD #14 - Great Circle Steering Error

SUBADDRESS: I06-14 Refresh Rate = 2.5/sec. Transmission = 50/sec.

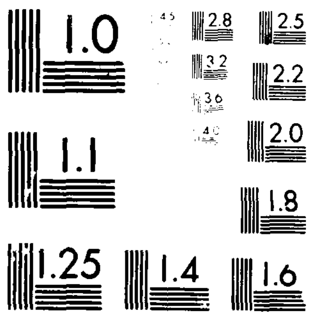
DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

AD-A084 036 AERONAUTICAL SYSTEMS DIV WRIGHT-PATTERSON AFB OH COMM--ETC F/G 17/7
CHARACTERISTIC FOR A MODERATE ACCURACY INERTIAL NAVIGATION SYST--ETC(U)
AUG 79

UNCLASSIFIED ASD/ENAC-77-1-REV-2 NL

3 OF 4
AD
A084036


1.0
2.8
2.5
3.2
2.2
3.6
4.0
1.1
2.0
1.8
1.25
1.4
1.6

WORD #15 - Computed Course Deviation

SUBADDRESS: I06-15 Refresh Rate = 2.5/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
io	LSB

WORD #16 - Time to Steerpoint

SUBADDRESS: 106-16 Refresh Rate = 2.5/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (32,768 seconds)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #17 - Distance to Steerpoint

SUBADDRESS: I06-17 Refresh Rate = 2.5/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (3276.8 Nautical Miles)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #18 - Relative Bearing To Steerpoint

SUBADDRESS: I06-18 Refresh Rate = 5/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #19 - Relative Bearing to nth Waypoint/Markpoint

SUBADDRESS: I06-19 Refresh Rate = 5/sec. Transmission Rate =50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #20 Time to nth Waypoint/Markpoint

SUBADDRESS: 106-20 Refresh Rate = 2.5/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (32,768 seconds)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #21 - Distance to nth Waypoint/Markpoint

SUBADDRESS: I06-21 Refresh Rate = 2.5/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (3276.8 Nautical Miles)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #22 INU Control Word 3

SUBADDRESS: I06-22 Refresh & Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Fix Freeze Flag acknowledge (See Note 1)
2	Fix Enter Flag acknowledge (See Note 1)
3	Mark Flag acknowledge (See Note 1)
4	Clear Flag acknowledge (See Note 1)
5	Data Ready Flag acknowledge (See Note 1)
6	MSB
7	*
8	** Present Steerpoint Code
9	LSB
10	MSB
11	** Present Waypoint/Markpoint Code
12	*
13	LSB
14	Illegal Command (See Note 2)
15	Position Error Valid
16	CADC Invalid

Note 1: This I06-22 bit shall be set to logic 1 in response to receiving a logic 1 in a corresponding bit in D01-02. The I06-22 bit being set to logic 1 shall cause the D01-02 bit to be reset to logic 0. Subsequent to the INU receiving this reset D01-02 bit, the INU shall reset the corresponding I06-22 bit to logic 0.

Note 2: A logic 1 shall indicate that the INU cannot comply with the command given in D01. When I06-22 bit 14 is set to logic 1, this shall cause D01-02 bit 5 to be reset to logic 0. Subsequent to when the D01-02 bit 5 is reset, then the I06-22 bit 14 shall be reset to logic 0.

WORDS #23, #24 - nth Waypoint/Markpoint Latitude

SUBADDRESS: I06-23, I06-24 Refresh Rate = 2.5/sec. Transmit Rate = 50/sec.

MSP / Word 23

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 24

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORDS #25, # 26- nth Waypoint/Markpoint Longitude

SUBADDRESS: I06-25, I06-26 Refresh Rate = 2.5/sec. Transmit Rate = 50/sec.

MSP / Word 25

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 26

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #27 - Selected Magnetic Course to Steerpoint

SUBADDRESS: 106-27 Refresh Rate 5/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #28 - Selected Magnetic Course

SUBADDRESS: I06-28 Refresh Rate = 5/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #29 - Magnetic Heading to nth Waypoint/Markpoint

SUBADDRESS: I06-29 Refresh Rate = 5/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD # 30 - True Air Speed

SUBADDRESS: I06- 30 Refresh Rate = 25/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (4096 knots)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD # 31 - Present Magnetic Ground Track

SUBADDRESS: I06-31 Refresh Rate = 5/sec. Transmission Rate = 50/sec.

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

SUBADDRESS: I07 Refresh Rate = 2.5/sec. Transmission Rate = 6.25/sec.

WORD #1 - nth Waypoint/Markpoint Spheroid/UTM Grid Zone (MSP)
Subaddress: I07-01

WORD #2 - nth Waypoint/Markpoint UTM Grid Zone (LSP)
Subaddress: I07-02

DATA FORMAT

DATA BIT	DESCRIPTION (WORD #1)	DESCRIPTION (WORD #2)
1	Logic "0"	Logic "0"
2	MSB	MSB
3	*	*
4	*	** UTM Grid Zone
5	** ASCII Code for Spheroid	** in ASCII
6	** Model (See Note 1)	*
7	*	*
8	LSB	LSB
9	Logic "0"	Logic "0"
10	MSB	MSB
11	*	*
12	** UTM Grid Zone (MSC)	* UTM Grid Zone (LSC)
13	** in ASCII (See Note 2)	* in ASCII (See Note 3)
14	*	*
15	*	*
16	LSB	LSB

WORD #3 - nth Waypoint/Markpoint UTM 100,000 Meter Zone
Subaddress: I07-03

DATA FORMAT

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	**UTM Area (MSC)
5	** in ASCII
6	*
7	*
8	LSB
9	Logic "0"
10	MSB
11	** UTM Area (LSC)
12	** in ASCII
13	*
14	*
15	*
16	LSB

Note 1: The code for the spheroid models is as follows:

Model	ASCII Code	Binary Value
International	0	0110000
Clark 1866	1	0110001
Clark 1880	2	0110010
Everest	3	0110011
Bessel	4	0110100
Australian Nat'l.	5	0110101
Airy	6	0110110
Hough	7	0110111
South American	8	0111000
Modified Everest	9	0111001
WGS-72	A	1000001

Note 2: MSC = Most significant character.
Note 3: LSC = Least significant character.

WORD #4 - nth Waypoint/Markpoint UTM Easting
Subaddress: I07-04

WORD #5 - nth Waypoint/Markpoint UTM Northing
Subaddress: I07-05

DATA FORMAT

DATA BIT	DESCRIPTION (WORD #4)	DESCRIPTION (WORD #5)
1	MSB (65,536 meters)	MSB (65,536 meters)
2	*	*
3	*	*
4	*	*
5	*	*
6	*	*
7	*	*
8	** UTM Easting	**UTM Northing
9	** (See Note 1)	** (See Note 1)
10	*	*
11	*	*
12	*	*
13	*	*
14	*	*
15	*	*
16	LSB (2 meters)	LSB (2 meters)

Note 1: The maximum value shall not exceed 99,998 meters.

WORDS #06, #07 - Present Position Latitude

SUBADDRESS: I07-06, I07-07

MSP / Word 06

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 07

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORDS #08, #09 - Present Position Longitude

SUBADDRESS: I07-08, I07-09

MSP / Word 08

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5 π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / WORD 09

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #10 - Present Position Spheroid/UTM Grid Zone (MSP)
Subaddress: I07-10

WORD #11 - Present Position UTM Grid Zone (LSP)
Subaddress: I07-11

DATA FORMAT

DATA BIT	DESCRIPTION (WORD #10)	DESCRIPTION (WORD #11)
1	Logic "0"	Logic "0"
2	MSB	MSB
3	*	** UTM Grid Zone
4	** ASCII Code for Spheroid Model	** in ASCII
5	** (See Note 1)	*
6	*	*
7	*	*
8	LSB	LSB
9	Logic "0"	Logic "0"
10	MSB	MSB
11	** UTM Grid Zone (MSC)	** UTM Grid Zone (LSC)
12	** in ASCII (See Note 2)	** in ASCII (See Note 3)
13	*	*
14	*	*
15	*	*
16	LSB	LSB

WORD #12 - Present Position UTM 100,000 meter zone
Subaddress: I07-12

DATA FORMAT

DATA BIT	DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	*
5	** UTM Area (MSC)
6	* in ASCII
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	** UTM Area (LSC)
13	** in ASCII
14	*
15	*
16	LSB

Note 1: The code for the Spheroid models are as follows:

Model	ASCII Code	Binary Value
International	0	0110000
Clark 1866	1	0110001
Clark 1880	2	0110010
Everest	3	0110011
Bessel	4	0110100
Australia	5	0110101
Airy	6	0110110
Hough	7	0110111
South American	8	0111000
Modified Everest	9	0111001
WGS-72	A	1000001

Note 2: MSC = Most significant character.
Note 3: LSC = Least significant character.

WORD #13 - Present Position UTM Easting
Subaddress: I07-13

WORD #14 - Present Position UTM Northing
Subaddress: I07-14

DATA FORMAT

DATA BIT	DESCRIPTION (WORD #13)	DESCRIPTION (WORD #14)
1	MSB (65,536 meters)	MSB (65,536 meters)
2	*	*
3	*	*
4	*	*
5	*	*
6	*	*
7	*	*
8	** UTM Easting	** UTM Northing
9	** (See Note 1)	** (See Note 1)
10	*	*
11	*	*
12	*	*
13	*	*
14	*	*
15	*	*
16	LSB (2 meters)	LSB (2 meters)

Note 1: The maximum value shall not exceed 99,998 meters.

WORD #15 - Entered True Heading

SUBADDRESS: 107-15

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5 π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #16 - Entered Magnetic Heading

SUBADDRESS: I07-16

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #17 - Entered Magnetic Variation

SUBADDRESS: 107-17

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	LSB
16	Steering Mode Code (See Note 1)

NOTE 1: Logic "0" for Great Circle Steering Mode. Logic "1" for Selected Course Steering.

WORD #18- Computed Magnetic Variation

SUBADDRESS: 107-18

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #19 - Align Time and Status

SUBADDRESS: I07-19

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB
2	*
3	*Alignment Status Code
4	** (SEE NOTE)
5	*
6	LSB
7	MSB (3072 seconds)
8	*
9	*
10	*
11	**Alignment Time
12	*
13	*
14	*
15	*
16	LSB (6 seconds)

NOTE: The following alignment status codes shall be used for operator information only and shall not imply system performance requirements.

BINARY CODE	STATUS CODE NAUTICAL MILES/HR
000000	Initial Condition
000001	Attitude Available
000010	Attitude and Heading Available
000011	8.0
000100	7.2
000101	6.4
000110	5.6
000111	4.8
001000	4.0
001001	3.2
001010	2.4
001011	1.6
001100	.8

WORD #20 - Wind Direction

SUBADDRESS: I07-20

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #21 - Wind Velocity/Last Mark Point Code

SUBADDRESS: I07-21

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (256 knots)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	LSB
14	MSB
15	** Last Mark Point Code (See Note 1)
16	LSB

Note 1: The location that the last Mark Point was loaded into shall be coded as follows:

000 No Mark Point
001 Mark Point A
010 Mark Point B
011 Mark Point C
100 Mark Point D
101 Mark Point E
110 Mark Point F

WORD #22 - Present Ground Speed

SUBADDRESS: I07- 22

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (2,048 knots)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #23 - Present True Ground Track

SUBADDRESS: I07-23

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #24 Predicted Ground speed

SUBADDRESS: I07-24

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (2,048 knots)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #25 - Present Convergence Factor in Use

SUBADDRESS: 107-25

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (1.0)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #26 Present Grid Heading

SUBADDRESS: 107-26

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #27 Desired Grid Heading

SUBADDRESS: I07-27

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (0.5π radians)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #28 - Position Error North — SUBADDRESS: I07-28

WORD #29 - Position Error East — SUBADDRESS: I07-29

DATA FORMAT

DATA BIT	DESCRIPTION (WORD #28)	DESCRIPTION (WORD #29)
1	Sign Bit	Sign Bit
2	MSB (163.84 Nautical Miles)	MSB (163.84 Nautical Miles)
3	*	*
4	*	*
5	*	*
6	*	*
7	*	*
8	*	*
9	*	*
10	*	*
11	*	*
12	*	*
13	*	*
14	*	*
15	*	*
16	LSB	LSB

REMARKS: These position errors are transmitted whenever either a Semi-Automatic (AUXILIARY) or Manual (OVERFLY) mode update is pending. Upon acceptance or rejection of an update, the position errors are reset to logic zero.

WORDS #30 - #32 - INU Miscellaneous Data

SUBADDRESS: I07-30, I07-31, I07-32

DATA BIT	I07-30 DESCRIPTION	I07-31 DESCRIPTION
1	Sign	Logic "0"
2	MSB	MSB
3	*	** ASCII Parameter
4	** ASCII Parameter	** (See Note 2)
5	** (MSC) (See Note 2)	*
6	*	*
7	*	*
8	LSB	LSB
9	Logic "0"	Logic "0"
10	MSB	MSB
11	*	*
12	* ASCII Parameter	* ASCII Parameter
13	* (See Note 2)	* (See Note 2)
14	*	*
15	*	*
16	LSB	LSB

DATA BIT	I07-32 DESCRIPTION
1	Logic "0"
2	MSB
3	*
4	** ASCII Parameter
5	** (See Note 2)
6	*
7	*
8	LSB
9	Logic "0"
10	MSB
11	*
12	** ASCII Parameter (LSC)
13	** (See Notes 1 & 2)
14	*
15	*
16	LSB

Note 1: Manufacturer's ID Codes

0110000	Singer
0110001	Litton Guidance Div
0110010	Rockwell
0110011	Litton Aero Products Div
0110100	Delco
0110101	Lear Seigler
0110110	Honeywell
0110111	Teledyne
0111000 thru 0111001	Unassigned Codes

Note 2: Non-printing and lower case characters shall not be used.

Note 3: In the absence of Miscellaneous Parameter Inserted Data ID Codes (Read or Insert), the I07-30 through I07-32 words shall contain the current data corresponding to the last received miscellaneous parameter code. (D01-03).

III. Unique CDU/CC to INU

SUBADDRESS: P01

WORD #1 - CDU MODE WORD

SUBADDRESS: P01-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	CDU Status
2	CDU Status Discrete 1
3	CDU Status Discrete 2
4	Power Supply Status
5	Logic "0"
6	Logic "0" Self-Test Bit
7	Logic "1" Self-Test Bit
8	Logic "1"
9	Logic "0"
10	Logic "0" Self-Test Bit
11	Logic "1" Self-Test Bit
12	Logic "1"
13	Logic "0"
14	Logic "0" Self-Test Bit
15	Logic "1" Self-Test Bit
16	Logic "0"

WORD #2 - Panel Switch Word No. 1

SUBADDRESS: P01-02

DATA FORMAT

DATA BIT	DESCRIPTION
1	* MSB
2	** DATA SEL Switch
3	* (See Note 1)
4	* LSB
5	* MSB
6	** FUNCTION Switch
7	* (See Note 2)
8	* LSB
9	* MSB
10	**Destination Thumbwheel
11	* (See Note 3)
12	* LSB
13	* } ALLOCATED
14	* } ALLOCATED
15	INU Power
16	Logic "O"

REMARKS:

BINARY CODE	(Note 1) CDU TRANS	(Note 2) CDU TRANS
0000	TEST	OFF
0001	ALLOCATED	STDR HDG
0010	STRG	NORM
0011	CRUSE	NAV
0100	ALT CAL	(SPARE)
0101	POS	FIX RADAR
0110	DEST	FIX TACAN
0111	WIND	FIX OVERFLY
1000	ALLOCATED	FIX HUD
1001	ALLOCATED	(SPARE)
1010	MISC	CAL
1011	(SPARE)	ATT

NOTE 3:

BINARY CODE	THUMBWHEEL
0 thru 9	0 thru 9
10 thru 12	A thru C
13 thru 15	D thru F

WORD #3 - Panel Switch Word No. 2

SUBADDRESS: P01-03

DATA FORMAT

DATA BIT	DESCRIPTION
1	* ALLOCATED
2	* ALLOCATED
3	* ALLOCATED
4	HUD READY
5	ALLOCATED
6	(SPARE READY)
7	ALLOCATED
8	DATA CHANGE
9	MODE SELECT (See Note 1)
10	DATA OPTION (See Note 1)
11	FAULT ACKNOWLEDGE (See Note 1)
12	MARK (See Note 2)
13	ALLOCATED
14	(SPARE READY)
15	(SPARE-PUSHBUTTON)
16	Logic "0"

REMARKS:

NOTE 1: Momentary contact switches - set when released, reset by software.

NOTE 2: Momentary contact switch - set when depressed, reset by software.

WORD #4 - Keyboard Function

SUBADDRESS: P01-04

DATA FORMAT

DATA BIT	DESCRIPTION
1	ENTER (See Note 1)
2	CLEAR (See Note 2)
3	KEYBOARD DEPRESS FLAG (See Note 3)
4	* (MSB)
5	** KEYBOARD BCD (See Note 4)
6	*
7	* (LSB)
8	Logic "0"
9	Logic "1"
10	Logic "0"
11	Logic "1"
12	Logic "0"
13	Logic "1"
14	Logic "0"
15	Logic "1"
16	Logic "0"

REMARKS:

NOTE 1: Momentary contact switch - set when released, reset by MUX transfer.

NOTE 2: Momentary contact switch - set while depressed.

NOTE 3: Momentary contact switch - set when keyboard enable switch is depressed and any key (0-9) is released, reset by MUX transfer.

NOTE 4: Set when any key (0-9) is depressed, remains set after key is released, reset by MUX transfer.

SUBADDRESS: P02

WORD #1 - *Backup* CDU Mode Word

SUBADDRESS: P02-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	CDU Status
2	CDU Status Discrete 1
3	CDU Status Discrete 2
4	Power Supply Status
5	Logic "0"
6	Logic "0" Self-Test Bit
7	Logic "1" Self-Test Bit
8	Logic "1"
9	Logic "0"
10	Logic "0" Self-Test Bit
11	Logic "1" Self-Test Bit
12	Logic "1"
13	Logic "0"
14	Logic "0" Self-Test Bit
15	Logic "1" Self-Test Bit
16	Logic "0"

WORD # 2 - *Backup* Panel Switch Word 1

SUBADDRESS: P02-02

DATA FORMAT

DATA BIT	DESCRIPTION
1	*MSB
2	**DATA SEL Switch
3	* (See Note 1)
4	*LSB
5	*MSB
6	**FUNCTION Switch
7	* (See Note 2)
8	*LSB
9	*MSB
10	** Destination Thumbwheel
11	* (See Note 3)
12	*LSB
13	* } ALLOCATED
14	* } ALLOCATED
15	INU POWER
16	Logic "0"

REMARKS:

BINARY CODE	DATA SELECT (Note 1)	FUNCTION (Note 2)
0000	TEST	OFF
0001	SPARE	STDR HDG
0010	STRG	NORM
0011	CRUSE	NAV
0100	ALT CAL	(SPARE)
0101	POS	FIX RDR
0110	DEST	FIX TCN
0111	WIND	FIX OVRFLY
1000	ALLOCATED	FIX HUD
1001	ALLOCATED	(SPARE)
1010	MISC	CAL
1011	(SPARE)	ATT

NOTE 3:

BINARY CODE	THUMBWHEEL
0 thru 9	0 thru 9
10 thru 12	A thru C
13 thru 15	D thru F

WORD # 3 - *Backup* Panel Switch Word 2

SUBADDRESS: P02-03

DATA FORMAT

DATA BIT	DESCRIPTION
1	* ALLOCATED
2	* ALLOCATED
3	* ALLOCATED
4	HUD READY
5	* ALLOCATED
6	(SPARE READY)
7	ALLOCATED
8	Data Change
9	Mode Select (See Note 1)
10	Data Option (See Note 1)
11	Fault Acknowledge (See Note 1)
12	Mark (See Note 2)
13	ALLOCATED
14	(SPARE READY)
15	(SPARE-PUSHBUTTON)
16	Logic "0"

REMARKS:

NOTE 1: Momentary contact switches - set when released, reset by software.

NOTE 2: Momentary contact switch - set when depressed, reset by software.

WORD # 4 - *Backup* Keyboard Function

SUBADDRESS: P02-04

DATA FORMAT

DATA BIT	DESCRIPTION
1	ENTER (See Note 1)
2	CLEAR (See Note 2)
3	Keyboard Depress Flag (See Note 3)
4	* (MSB)
5	** Keyboard BCD (See Note 4)
6	*
7	* (LSB)
8	Logic "0"
9	Logic "1"
10	Logic "0"
11	Logic "1"
12	Logic "0"
13	Logic "1"
14	Logic "0"
15	Logic "1"
16	Logic "0"

REMARKS:

NOTE 1: Momentary contact switch - set when released, reset by MUX transfer.

NOTE 2: Momentary contact switch - set while depressed.

NOTE 3: Momentary contact switch - set when keyboard enable switch is depressed and any key (0-9) is released, reset by MUX transfer.

NOTE 4: Set when any key (0-9) is depressed, remains set after key is released, reset by MUX transfer.

SUBADDRESS: F01

WORD #1 - CC/INU/CDU MODE WORD

SUBADDRESS: F01-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	CDU Status
2	CDU Status Discrete 1
3	CDU Status Discrete 2
4	Power Supply Status
5	Logic "0"
6	Logic "0" Self-Test Bit
7	Logic "1" Self-Test Bit
8	Logic "1"
9	Logic "0"
10	Logis "0" Self-Test Bit
11	Logic "1" Self-Test Bit
12	Logic "1"
13	Logic "0"
14	Logic "0" Self-Test Bit
15	Logic "1" Self-Test Bit
16	Logic "0"

WORD #2 - Panel Switch #1

SUBADDRESS: F01-02

DATA FORMAT

DATA BIT	DESCRIPTION
1	*MSB
2	**Data Sel Switch
3	* See Note 1
4	*LSB
5	*MSB
6	**Function Switch
7	* See Note 2
8	*LSB
9	*MSB
10	**Destination Thumbwheel
11	* See Note 3
12	*LSB
13	* } ALLOCATED
14	* } ALLOCATED
15	INU Power
16	Logic "0"

REMARKS:

BINARY CODE	(NOTE 1) CDU TRANS	(NOTE 2) CDU TRANS
0000	TEST	OFF
0001	ALLOCATED	STOR HDG
0010	STRG	NORM
0011	CRUISE	NAV
0100	ALT CAL	(SPARE)
0101	POS	FIX RADAR
0110	DEST	FIX TACAN
0111	WIND	FIX OVRFLY
1000	ALLOCATED	FIX HUD
1001	ALLOCATED	(SPARE)
1010	MISC	CAL
1011	(SPARE)	ATT

NOTE 3:

BINARY CODE	THUMBWHEEL
0 thru 9	0 thru 9
10 thru 12	A thru C
13 thru 15	D thru F

WORD #3 - Panel Switch Word #2

SUBADDRESS: F01-03

DATA FORMAT

DATA BIT	DESCRIPTION
1	* ALLOCATED
2	* ALLOCATED
3	* ALLOCATED
4	HUD READY
5	ALLOCATED
6	(SPARE READY)
7	ALLOCATED
8	Data Change
9	Mode Select (See Note 1)
10	Data Option (See Note 1)
11	Fault Acknowledge (See Note 1)
12	Mark (See Note 2)
13	ALLOCATED
14	(SPARE-READY)
15	(Spare - Pushbutton)
16	Logic "0"

REMARKS:

NOTE 1: Momentary contact switches - set when released, reset by software.

NOTE 2: Momentary contact switch - set when depressed, reset by software.

WORD #4 - Keyboard Function

SUBADDRESS: F01-04

DATA FORMAT

DATA BIT	DESCRIPTION
1	Enter (See Note 1)
2	Clear (See Note 2)
3	Keyboard Depress Flag (See Note 3)
4	*MSB
5	**Keyboard BCD (See Note 4)
6	*
7	*LSB
8	Logic "0"
9	Logic "1"
10	Logic "0"
11	Logic "1"
12	Logic "0"
13	Logic "1"
14	Logic "0"
15	Logic "1"
16	Logic "0"

REMARKS:

NOTE 1: Momentary contact switch - set when released, reset by MUX transfer.

NOTE 2: Momentary contact switch - set while depressed.

NOTE 3: Momentary contact switch - set when keyboard enable switch is depressed and any key (0-9) is released, reset by MUX transfer.

NOTE 4: Set when any key (0-9) is depressed, remains set after key is released, reset by MUX transfer.

WORD #5 - Alpha Display Left Character

SUBADDRESS: F01-05

DATA FORMAT

DATA BIT	DESCRIPTION
1	*MSB
2	*
3	***Left Character (See Note 1)
4	*
5	*
6	*LSB
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	LMD Minute
13	LMD Degree
14	LMD Decimal
15	LMD Geographic/Arithmetic (See Note 2)
16	LMD Direction (See Note 3)

REMARKS:

NOTE 1:

BIN CODE	DISPLAY
0 thru 9	0 thru 9
10 thru 35	A thru Z
36	+
37	-
38	/
39	All segments
63	Blank

NOTE 2:

CODE	DESCRIPTION
0	Geographic
1	Arithmetic

NOTE 3:

DIR CODE	DISPLAY
0	N
1	S, -

WORD #6 - Alpha Display Middle Character

SUBADDRESS: F01-06

DATA FORMAT

DATA BIT	DESCRIPTION
1	*MSB
2	*
3	**Middle Character (See Note)
4	*
5	*
6	*LSB
7	NAV Ready (Lamp)
8	Data Change (Lamp and Keyboard Enable)
9	Mode Select (Logic Reset of P01-03 BIT 9)
10	Data Option (Logic Reset of P01-03 BIT 10)
11	Fault Acknowledge (Logic Reset of P01-03 BIT 11)
12	Mark (Logic Reset of P01-03 BIT 12)
13	Bite Initiate (Logic Set)
14	Avionics Caution (Logic Set)
15	Mode Select (Lamp)
16	Random 1's and 0's

REMARKS:

NOTE:

BINARY CODE	DISPLAY
0 thru 9	0 thru 9
10 thru 35	A thru Z
36	+
37	-
38	/
39	All Segments
63	Blank

WORD #7 - Alpha Display Right Character

SUBADDRESS: F01-07

DATA FORMAT

DATA BIT	DESCRIPTION
1	*MSB
2	*
3	***Right Character (See Note 1)
4	*
5	*
6	*LSB
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	RMD Decimal (after MSD)
12	RMD Minute
13	RMD Degree
14	RMD Decimal
15	RMD Geographic/Arithmetic (See Note 2)
16	RMD Direction (See Note 3)

REMARKS:

NOTE 1:

BIN CODE	DISPLAY
0 thru 9	0 thru 9
10 thru 35	A thru Z
36	+
37	-
38	/
39	All Segments
63	Blank

NOTE 2:

CODE	DESCRIPTION
0	Geographic
1	Arithmetic

NOTE 3:

DIR CODE	DISPLAY
0	E
1	W, -

IV. INU to Unique CDU/CC

SUBADDRESS: I02

WORD #1 - INU Mode Word

SUBADDRESS: I02-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	ATT REF Fail (Note 1)
2	Navigation Fail (Note 2)
3	Degraded Navigation
4	Navigation Data Unavailable (Note 3)
5	DIG ATT Data Invalid (Note 4)
6	In Fine Align (Note 5)
7	In Coarse Align (Note 6)
8	Control Vector Acknowledge
9	Altitude Loop Bit (Note 7)
10	INU In Self Test
11	Pole Flag
12	In Manual Magnetic Variation
13	SPARE
14	SPARE
15	CDU Fail
16	Logic "0"

REMARKS: A logic "1" shall indicate that the referenced condition is true.

NOTE 1: The platform has failed and no navigation or attitude data is available.

NOTE 2: The INU computer has failed. Attitude outputs are still valid.

NOTE 3: The INU is not in the NAV mode. Position and velocity data are not being calculated.

NOTE 4: Is invalid due to A/D converter or platform failure.

NOTE 5: NAV mode may be entered. ATT and HDG data are valid.

NOTE 6: ATT data is available. HDG data is not available. NAV mode may not be entered.

NOTE 7: Baro-inertial altitude data is invalid.

WORD #2 - Alpha Display Left Character

SUBADDRESS: 102-02

DATA FORMAT

DATA BIT	DESCRIPTION
1	*(MSB)
2	*
3	***Left Character (See Note 1)
4	*
5	*
6	*(LSB)
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	LMD Minute
13	LMD Degree
14	LMD Decimal
15	LMD Geographic/Arithmetic (See Note 2)
16	LMD Direction (See Note 3)

REMARKS:

NOTE:

(1) BIN CODE	(1) DISPLAY	(2) CODE	(2) DESCRIPTION	(3) DIR CODE	(3) DISPLAY
0 thru 9	0 thru 9	0	Geographic	0	N
10 thru 35	A thru Z	1	Arithmetic	1	S, -
36	+				
37	-				
38	/				
39	All Segments				
63	Blank				

WORD #3 - Alpha Display Middle Character

SUBADDRESS: I02-03

DATA FORMAT

DATA BIT	DESCRIPTION
1	*(MSB)
2	*
3	**Middle Character (See Note)
4	*
5	*
6	*(LSB)
7	NAV Ready (Lamp)
8	Data Change (Lamp and Keyboard Enable)
9	Mode Select (Logic Reset of P01-03 Bit 9)
10	Data Option (Logic Reset of P01-03 Bit 10)
11	Fault Acknowledge (Logic Reset of P01-03 Bit 11)
12	Mark (Logic Reset of P01-03 Bit 12)
13	Bite Initiate (Logic Set)
14	Avionics Caution (Logic Set)
15	Mode Select (Lamp)
16	Random 1's and 0's

REMARKS:

NOTE:

BINARY CODE	DISPLAY
0 thru 9	0 thru 9
10 thru 35	A thru Z
36	+
37	-
38	/
39	All Segments
63	Blank

WORD #4 - Alpha Display Right Character

SUBADDRESS: 102-04

DATA FORMAT

DATA BIT	DESCRIPTION
1	*(MSB)
2	*
3	***Right Character (See Note 1)
4	*
5	*
6	*(LSB)
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	RMD Decimal (After MSD)
12	RMD Minute
13	RMD Degree
14	RMD Decimal
15	RMD Geographic/Arithmetic (See Note 2)
16	RMD Direction (See Note 3)

REMARKS:

NOTE:

(1)		(2)		(3)	
BIN CODE	DISPLAY	CODE	DESCRIPTION	DIR CODE	DISPLAY
0 thru 9	0 thru 9	0	Geographic	0	E
10 thru 35	A thru Z	1	Arithmetic	1	W, -
36	+				
37	-				
38	/				
39	All Segments				
63	Blank				

WORD #5 - Left MISC Display

SUBADDRESS: I02-05

MSP / Word 5

DATA FORMAT

DATA BIT	DESCRIPTION
1	Random 1's and 0's
2	Random 1's and 0's
3	Random 1's and 0's
4	MSD Flag (Note 1)
5	4th LSD Flag (Note 1)
6	3rd LSD Flag (Note 1)
7	2nd LSD Flag (Note 1)
8	LSD Flag (Note 1)
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	*(MSB)
14	**(MSD) (Note 2)
15	*
16	*(LSB)

WORD #6 - Left MISC Display

SUBADDRESS: I02-06

LSP / Word 6

DATA FORMAT

DATA BIT	DESCRIPTION
1	*(MSB)
2	**4th LSD (Note 2)
3	*
4	*(LSB)
5	*(MSB)
6	****3rd LSD (Note 2)
7	*
8	*(LSB)
9	*(MSB)
10	**2nd LSD (Note 2)
11	*
12	*(LSB)
13	*(MSB)
14	****LSD (Note 2)
15	*
16	*(LSB)

REMARKS:

NOTE: ---------(1)---------

CODE	FLAG
0	BCD
1	ALPHA

---------(2)---------

BIN CODE	CDU DISP
0 thru 9	0 thru 9
15	Blank

ALPHA CODE	CDU DISP
16	-
17	A
18	C
19	E

---------(2)---------

ALPHA CODE	DISP
20	F
21	G
22	H
23	J
24	L
25	P
26	U
27	Y

WORD #7 - Right MISC Display

SUBADDRESS: 102-07

MSP / Word 7

DATA FORMAT

DATA BIT	DESCRIPTION
1	Random 1's and 0's
2	Random 1's and 0's
3	Random 1's and 0's
4	Random 1's and 0's
5	Random 1's and 0's
6	Random 1's and 0's
7	Random 1's and 0's
8	Random 1's and 0's
9	*(MSB)
10	**MSD (See Note)
11	*
12	*(LSB)
13	*(MSB)
14	**5th LSD (See Note)
15	*
16	*(LSB)

WORD #8 - Right MISC Display

SUBADDRESS: I02-08

LSP / Word 8

DATA FORMAT

DATA BIT	DESCRIPTION
1	*(MSB)
2	**4th LSD (See Note)
3	*
4	*(LSB)
5	*(MSB)
6	**3rd LSD (See Note)
7	*
8	*(LSB)
9	*(MSB)
10	**2nd LSD (See Note)
11	*
12	*(LSB)
13	*(MSB)
14	**LSD (See Note)
15	*
16	*(LSB)

REMARKS:

NOTE: ----------------------

BINARY CODE	CDU DISP
0 thru 9	0 thru 9
15	Blank

WORD #9 - INU BITE Summary Word 1

SUBADDRESS: I02-09

DATA FORMAT

DATA BIT	DESCRIPTION
1	
2	
3	
4	
5	
6	
7	
8	See Note
9	
10	
11	
12	
13	
14	
15	
16	

NOTE: Each INS manufacturer shall specify BIT assignment description per his equipment design.

WORD #10 - INU BITE Summary Word 2

SUBADDRESS: I02-10

DATA FORMAT

DATA BIT	DESCRIPTION
1	
2	
3	
4	
5	
6	
7	
8	See Note 1
9	
10	
11	
12	
13	
14	
15	** ID CODE (SEE NOTE 2)
16	*

NOTE 1: Each INS manufacturer shall describe the BIT assignments per his equipment design.

NOTE 2: Manufacturers ID Codes

00	Singer
01	Litton
10	Rockwell
11	Spare

SUBADDRESS: I03

WORD #1 - INU Mode Word

SUBADDRESS: I03-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	Att Ref Fail (Note 1)
2	Navigation Fail (Note 2)
3	Degraded Navigation
4	Navigation Data Unavailable (Note 3)
5	Dig Att Data Invalid (Note 4)
6	In Fine Align (Note 5)
7	In Coarse Align (Note 6)
8	Control Vector Acknowledge
9	Altitude Loop Bit (Note 7)
10	INU in Self-test
11	Pole Flag
12	In Manual Magnetic Variation
13	Spare
14	Spare
15	CDU Fail
16	Logic "0"

REMARKS: A logic "1" shall indicate that the referenced condition is true.

NOTE 1: The platform has failed and no navigation or attitude data is available.

NOTE 2: The INU computer has failed. Attitude outputs are still valid.

NOTE 3: The INU is not in the Nav mode. Position and velocity data are not being calculated.

NOTE 4: Is invalid due to A/D converter or platform failure.

NOTE 5: Nav mode may be entered. Att and Hdg data are valid.

NOTE 6: Att data is available. Hdg data is not available. Nav mode may not be entered.

NOTE 7: Baro-Inertial Altitude data is invalid.

WORD #2 - Alpha Display Left Character

SUBADDRESS: 103-02

DATA FORMAT

DATA BIT	DESCRIPTION
1	*MSB
2	*
3	***Left Character (See Note 1)
4	*
5	*
6	*LSB
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	LMD Minute
13	LMD Degree
14	LMD Decimal
15	LMD Geographic/Arithmetic (See Note 2)
16	LMD Direction (See Note 3)

REMARKS:

NOTE 1:

BIN CODE	DISPLAY
0 thru 9	0 thru 9
10 thru 35	A thru Z
36	+
37	-
38	/
39	All Segments
63	Blank

NOTE 2:

CODE	DESCRIPTION
0	Geographic
1	Arithmetic

NOTE 3:

DIR CODE	DISPLAY
0	N
1	S, -

WORD #3 - Alpha Display Middle Character

SUBADDRESS: I03-03

DATA FORMAT

DATA BIT	DESCRIPTION
1	*MSB
2	*
3	**Middle Character (See Note)
4	*
5	*
6	*LSB
7	Nav Ready (Lamp)
8	Data Change (Lamp & Keyboard Enable)
9	Mode Select (Logic Reset of P02-03 Bit 9)
10	Data Option (Logic Reset of P02-03 Bit 10)
11	Fault Acknowledge (Logic Reset of P02-03 Bit 11)
12	Mark (Logic Reset of P02-03 Bit 12)
13	Bite Initiate (Logic Set)
14	Avionics Caution (Logic Set)
15	Mode Select (Lamp)
16	Random 1's and 0's

REMARKS:

NOTE:

BINARY CODE	DISPLAY
0 thru 9	0 thru 9
10 thru 35	A thru Z
36	+
37	-
38	/
39	All Segments
63	Blank

WORD #4 - Alpha Display Right Character

SUBADDRESS: I03-04

DATA FORMAT

DATA BIT	DESCRIPTION
1	*MSB
2	*
3	***Right Character (See Note 1)
4	*
5	*
6	*LSB
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	RMD Decimal (after MSD)
12	RMD Minute
13	RMD Degree
14	RMD Decimal
15	RMD Geographic/Arithmetic (See Note 2)
16	RMD Direction (See Note 3)

REMARKS:

NOTE 1:

BIN CODE	DISPLAY
0 thru 9	0 thru 9
10 thru 35	A thru Z
36	+
37	-
38	/
39	All Segments
63	Blank

NOTE 2:

CODE	DESCRIPTION
0	Geographic
1	Arithmetic

NOTE 3:

DIR CODE	DISPLAY
0	E
1	W, -

WORD #5 - LMIS Display

SUBADDRESS: 103-05

DATA FORMAT

DATA BIT	DESCRIPTION
1	Random 1's and 0's
2	Random 1's and 0's
3	Random 1's and 0's
4	MSD Flag (Note 1)
5	4th LSD Flag (Note 1)
6	3rd LSD Flag (Note 1)
7	2nd LSD Flag (Note 1)
8	LSD Flag (Note 1)
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	*MSB
14	**MSD (Note 2)
15	*
16	*LSB

REMARKS:

NOTE 1:

CODE	FLAG
0	BCD
1	Alpha

NOTE 2:

BINARY CODE	CDU DISP
0 thru 9	0 thru 9
15	Blank

ALPHA CODE	CDU DISP
16	-
17	A
18	C
19	E
20	F
21	G
22	H
23	J
24	L
25	P
26	U
27	Y

WORD #6 - LMIS Display

SUBADDRESS: 103-06

DATA FORMAT

DATA BIT	DESCRIPTION
1	*(MSB)
2	**4th LSD (Note 1)
3	*
4	*(LSB)
5	*(MSB)
6	****3rd LSD (Note 1)
7	*
8	*(LSB)
9	*(MSB)
10	**2nd LSD (Note 1)
11	*
12	*(LSB)
13	*(MSB)
14	****LSD (Note 1)
15	*
16	*(LSB)

REMARKS:

NOTE 1:

BINARY CODE	CDU DISP
0 thru 9	0 thru 9
15	Blank

ALPHA CODE	CDU DISP
16	-
17	A
18	C
19	E
20	F
21	G
22	H
23	J
24	L
25	P
26	U
27	Y

WORD #7 - RMISC DISPLAY

SUBADDRESS: I03-07

DATA FORMAT

DATA BIT	DESCRIPTION
1	Random 1's & 0's
2	Random 1's & 0's
3	Random 1's & 0's
4	Random 1's & 0's
5	Random 1's & 0's
6	Random 1's & 0's
7	Random 1's & 0's
8	Random 1's & 0's
9	*MSB
10	*MSG (See Note)
11	*
12	*LSB
13	*
14	**5th LSD (See Note)
15	*
16	*

WORD #8 - RMISC DISPLAY

SUBADDRESS: I03-08

DATA FORMAT

DATA BIT	DESCRIPTION
1	*(MSB)
2	**4th LSD (See Note)
3	*
4	*(LSB)
5	*(MSB)
6	**3rd LSD (See Note)
7	*
8	*(LSB)
9	*(MSB)
10	**2nd LSD (See Note)
11	*
12	*(LSB)
13	*(MSB)
14	**LSD (See Note)
15	*
16	*(LSB)

REMARKS:

NOTE:

BINARY CODE	CDU DISP
0 thru 9	0 thru 9
15	Blank

V. Filter/Sensor to INU (Correction Vector)

SUBADDRESS: F02

WORD #1 - INU Mode Word

SUBADDRESS: F02-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	Spare
2	Filter Mode (See Note 1)
3	Spare
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

NOTE 1: When the unique CDU function switch is placed in the "NAV" mode position before the INU reaches "NAV Ready" align status, the INU automatically enters the "Attitude" mode. Subsequent receipt of the Filter Mode bit set to logic 1 shall force the INU into the "NAV" mode. Use of the Filter Mode bit with the Generalized CDU shall be consistant with D01-02, Note 4.

F02 - Correction Vector

An external computer shall transmit the following correction vector to the INU as required. The correction vector states are:

a. CXX (F02-02,03)
b. CXY (F02-04,05)
c. CXZ (F02-06,07)
d. Longitude (F02-08,09)
e. Velocity correction - x (F02-10)
f. Velocity correction - y (F02-11)
g. Tilt correction - x (F02-12)
h. Tilt correction - y (F02-13)
i. Gyro bias correction - x (F02-14)
j. Gyro bias correction - y (F02-15)
k. Gyro bias correction - z (F02-16)

When message block F02 is received, states a through c will have an RSS value of 1 as computed externally. The INU direction cosines shall be updated to agree with states a through c, the switching wander angle shall be updated to the corresponding wander angle and the switching longitude shall be updated to agree with state d.

Velocities shall be corrected according to states e and f. The above correction shall be performed and the control vector acknowledge bit (CVAB) in the INU Mode/Control word shall be set during the first 50/sec computation cycle following the reception of the control vector. The CVAB shall be reset 40 msec after being set.

The removal of tilt errors according to states g and h and the application of gyro biases according to states i through k shall begin at the first calculation of torquing rates following the reception of the control vector. Tilts shall be corrected at the highest rate consistent with normal torquing rates and maximum accurate torquing rates. Externally generated gyro biases shall be set equal to zero at INU power on. Tilt corrections are cumulative in that new tilt corrections are added to the previous corrections which have not yet been applied to the platform. Gyro biases are also cumulative.

States a through c contain the 3 platform to earth direction cosines which, with longitude, define the location of the aircraft relative to the earth. These cosines can be expressed as

$$C_{XX} = \text{cosine } \gamma \text{ cosine } \alpha$$

$$C_{XY} = -\text{cosine } \gamma \sin \alpha$$

$$C_{XZ} = +\sin \gamma$$

where γ = latitude and α = wander angle.

WORD #2 - CXX

SUBADDRESS: F02-02

MSP / Word 2

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

REMARKS: LSB Approx 2.4 EXP-7

WORD #3 - CXX

SUBADDRESS: F02-03

LSP / Word 3

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	LSB (1/4,194,304)
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

WORD #4 - CXY

SUBADDRESS: F02-04

MSP / Word 4

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #5 - CXY

SUBADDRESS: F02-05

LSP / Word 5

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	LSB (1/4,194,304)
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

WORD #6 - CXZ

SUBADDRESS: F02-06

MSP / Word 6

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #7 - CXZ

SUBADDRESS: F02-07

LSP / Word 7

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	LSB (1/4,194,304)
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS: LSB Approx 2.4 EXP-7

WORD #8 - Longitude

SUBADDRESS: F02-08

MSP / Word 8

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #9 - Longitude

SUBADDRESS: F02-09

LSP / Word 9

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	LSB (1/8,388,608)
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

WORD #10 - VEL CORX

SUBADDRESS: F02-10

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (1/4 FPS)

WORD #11 - VEL CORY

SUBADDRESS F02-11

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (1/4 FPS)

WORD #12 - TILT CORX

SUBADDRESS: F02-12

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16,384 Arc Sec)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (1 Arc Sec)

WORD #13 - TILT CORY

SUBADDRESS: F02-13

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16,384 Arc Sec)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (1 Arc Sec)

WORD #14 - Gyro Bias CORX

SUBADDRESS: F02-14

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/16,384) Rad/Sec)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #15 - Gyro Bias CORY

SUBADDRESS: F02-15

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/16,384) Rad/Sec)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

WORD #16 - Gyro bias CORZ

SUBADDRESS: F02-16

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/16,384) Rad/Sec)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

REMARKS: MSB Approx. 6.1 EPX-5 RAD/SEC
LSB Approx. 3.7 EPX-9 RAD/SEC

VI. INS State Vector

SUBADDRESS: I01

WORD #1 - INU Mode Word

SUBADDRESS: I01-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	Att Ref Fail (Note 1)
2	Navigation Fail (Note 2)
3	Degraded Navigation
4	Navigation Data Unavailable (Note 3)
5	Dig Att Data Invalid (Note 4)
6	In Fine Align (Note 5)
7	In Coarse Align (Note 6)
8	Control Vector Acknowledge
9	Altitude Loop Bit (Note 7)
10	INU in Self-test
11	Pole Flag
12	In Manual Magnetic Variation
13	Spare
14	Spare
15	CDU Fail
16	Logic "0"

REMARKS: A logic "1" shall indicate that the referenced condition is true.

NOTE 1: The platform has failed and no navigation or attitude data is available.

NOTE 2: The INU computer has failed. Attitude outputs are still valid.

NOTE 3: The INU is not in the Nav mode. Position and velocity data are not being calculated.

NOTE 4: Is invalid due to A/D converter or platform failure.

NOTE 5: Nav mode may be entered. Att and Hdg data are valid.

NOTE 6: Att data is available. Hdg data is not available. Nav mode may not be entered.

NOTE 7: Baro-Inertial altitude data is invalid.

WORD #2 - Time Tag

SUBADDRESS: I01-02

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (2,097,152 Microsec)
2	
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (64 microsec)

WORD #3 - Velocity X

SUBADDRESS: I01-03

MSP / Word 3

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #4 - Velocity X

SUBADDRESS: I01-04

LSP / Word 4

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	LSB (1/64 FPS)
5	Random 1's and 0's
6	Random 1's and 0's
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

WORD # 5 - Velocity Y

SUBADDRESS: I01-05

MSP / Word 5

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #6 - Velocity Y

SUBADDRESS: I01-06

LSP / Word 6

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	LSB (1/64 FPS)
5	Random 1's and 0's
6	Random 1's and 0's
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

WORD #7 - Velocity Z

SUBADDRESS: I01-07

MSP / Word 7

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #8 - Velocity Z

SUBADDRESS: I01-08

LSP / Word 8

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	LSB (1/64 FPS)
5	Random 1's and 0's
6	Random 1's and 0's
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

WORD #9 - Platform Azimuth

SUBADDRESS: I01-09

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	LSB (1/8,192)
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

ACCURACY: 0.00175 radians RMS angle error between X axis and INU boresight.

A to D converter resolution is equal to Tan Theta divided by 1024 for Theta between 0 and 45 degrees in each octant.

WORD # 10 - Roll

SUBADDRESS: I01-10

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	LSB (1/8,192)
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

ACCURACY: 0.00175 radians RMS.

Positive sense is right bank (right wing down).

A to D converter resolution is equal to Tan Theta divided by 1024 for Theta between 0 and 45 degrees in each octant.

WORD #11 - Pitch

SUBADDRESS: I01-11

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	LSB (1/8,192)
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

ACCURACY: 0.00175 radians RMS.

Positive sense is nose up.

A to D converter resolution is equal to Tan Theta divided by 1024 for Theta between 0 and 45 degrees in each octant.

WORD #12 - True Heading

SUBADDRESS: I01-12

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	LSB (1/8,192)
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

ACCURACY: 0.00175 radians RMS.

Positive sense is CW WRT true north.

A to D converter resolution is equal to Tan Theta divided by 1024 for Theta between 0 and 45 degrees in each octant.

WORD #13 - Magnetic Heading

SUBADDRESS: I01-13

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	LSB (1/8,192)
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

ACCURACY: 0.0035 radians RMS.

Positive sense is CW WRT magnetic north.

A to D converter resolution is equal to Tan Theta divided by 1024 for Theta between 0 and 45 degrees in each octant.

WORD #14 - Acceleration X

SUBADDRESS: I01-14

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	LSB (1)
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

Specification Accuracy: 0.064 ft. per second squared RMS.

Resolution for 1/50 of a second interval is 1.6 ft. per second squared, and for 1 second interval is 0.032 ft. per sec. squared.

WORD #15 - Y Acceleration

SUBADDRESS: I01-15

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	LSB (1)
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

Specification Accuracy: 0.064 ft. per second squared RMS.

Resolution for 1/50 of a second interval is 1.6 ft. per second squared, and for 1 second interval is 0.032 ft. per second squared.

WORD #16 - Z Acceleration

SUBADDRESS: I01-16

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	LSB (1)
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

Specification accuracy: 0.064 ft. per second squared RMS.

Acceleration consists of accelerometer reading plus Coriolis compensation. The static condition output reading shall be approximately one g.
Resolution for 1/50 of a second interval is 1.6 ft. per second squared, and for 1 second interval is 0.032 ft. per second squared.

NOTE: The following words #17-#24 (I01-17 thru I01-24) contain "pure inertial" information.

WORD #17 - CXX

SUBADDRESS: I01-17

MSP / Word 17

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #18 - CXX

SUBADDRESS: I01-18

LSP / Word 18

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	LSB (1/4,194,304)
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

WORD #19 - CXY

SUBADDRESS: I01-19

MSP / Word 19

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #20 - CXY

SUBADDRESS: I01-20

LSP / Word 20

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	LSB (1/4,194,304)
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

WORD #21 - CXZ

SUBADDRESS: I01-21

MSP / Word 21

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #22 - CXZ

SUBADDRESS: I01-22

LSP / Word 22

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	LSB (1/4,194,304)
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

WORD #23 - Longitude

SUBADDRESS: I01-23

MSP / Word 23

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #24 - Longitude

SUBADDRESS: I01-24

LSP / Word 24

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	*
5	*
6	*
7	*
8	LSB (1/8,388,608)
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

WORD #25 - Inertial Altitude

SUBADDRESS: I01-25

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (65,536 ft.)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (4 ft.)

REMARKS:

Positive direction is up.

Altitude cannot go from a negative value to a positive value (or visa versa) without passing through 0.

WORD #26 - GREAT CIRCLE STEERING ERROR

SUBADDRESS: I01-26

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (1/32,768)

REMARKS:

LSB Approx. 3 EXP-5

WORD #27 - X-Axis Residual Tilt

SUBADDRESS: I01-27

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16,384 Arc Sec)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (1 Arc Sec)

WORD #28 - Y-Axis Residual Tilt

SUBADDRESS: I01-28

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (16,384 Arc Sec)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (1 Arc Sec)

SUBADDRESS: I04, I05

WORD #1 - INU Mode Word

SUBADDRESS: I04-01, I05-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	Att Ref Fail (Note 1)
2	Navigation Fail (Note 2)
3	Degraded Navigation
4	Navigation Data Unavailable (Note 3)
5	Dig Att Data Invalid (Note 4)
6	In Fine Align (Note 5)
7	In Coarse Align (Note 6)
8	Control Vector Acknowledge
9	Altitude Loop Bit (Note 7)
10	INU in Self-Test
11	Pole Flag
12	In Manual Magnetic Variation
13	Spare
14	Spare
15	CDU Fail
16	Logic "0"

REMARKS: A logic "1" shall indicate that the referenced condition is true.

NOTE 1: The platform has failed and no navigation or attitude data is available.

NOTE 2: The INU computer has failed. Attitude outputs are still valid.

NOTE 3: The INU is not in the Nav mode. Position and velocity data are not being calculated.

NOTE 4: Is invalid due to A/D converter or platform failure.

NOTE 5: Nav mode may be entered. Att and Hdg data are valid.

NOTE 6: Att data is available. Hdg data is not available. Nav mode may not be entered.

NOTE 7: Baro-inertial altitude data is invalid.

WORD #2 - Time Tag

SUBADDRESS: I04-02, I05-02

DATA FORMAT

DATA BIT	DESCRIPTION
1	MSB (2,097,152 Microsec)
2	*
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (64 microsec)

WORD #3 - Velocity X

SUBADDRESS: I04-03, I05-03

MSP / Word 3

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #4 - Velocity X

SUBADDRESS: I04-04, I05-04

LSP / Word 4

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	LSB (1/64 FPS)
5	Random 1's and 0's
6	Random 1's and 0's
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

WORD #5 - Velocity Y

SUBADDRESS: I04-05, I05-05

MSP / Word 5

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #6 - Velocity Y

SUBADDRESS: I04-06, I05-06

LSP / Word 6

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	LSB (1/64 FPS)
5	Random 1's and 0's
6	Random 1'saand 0's
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

WORD #7 - Velocity Z

SUBADDRESS: I04-07, I05-07

MSP / Word 7

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (4096 FPS)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

WORD #8 - Velocity Z

SUBADDRESS: I04-08, I05-08

LSP / Word 8

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	*
4	LSB (1/64 FPS)
5	Random 1's and 0's
6	Random 1's and 0's
7	Random 1's and 0's
8	Random 1's and 0's
9	Random 1's and 0's
10	Random 1's and 0's
11	Random 1's and 0's
12	Random 1's and 0's
13	Random 1's and 0's
14	Random 1's and 0's
15	Random 1's and 0's
16	Random 1's and 0's

WORD #9 - Platform Azimuth

SUBADDRESS: I04-09, I05-09

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	LSB (1/8,192)
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

ACCURACY: 0.00175 radians RMS angle error between X axis and INU boresight.

A to D converter resolution is equal to Tan Theta divided by 1024 for Theta between 0 and 45 degrees in each octant.

WORD #10 - Roll

SUBADDRESS: I04-10, I05-10

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	LSB(1/8,192)
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

ACCURACY: 0.00175 radians RMS.

Positive sense is right bank (right wing down).

A to D converter resolution is equal to Tan Theta divided by 1024 for Theta between 0 and 45 degrees in each octant.

WORD #11 - Pitch

SUBADDRESS: I04-11, 105-11

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	LSB (1/8,192)
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

ACCURACY: 0.00175 radians RMS.

Positive sense is nose up.

A to D converter resolution is equal to Tan Theta divided by 1024 for Theta between 0 and 45 degrees in each octant.

WORD #12 - True Heading

SUBADDRESS: I04-12, I05-12

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	LSB (1/8,192)
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

ACCURACY: 0.00175 radians RMS.

Positive sense is CW WRT true north.

A to D converter resolution is equal to Tan Theta divided by 1024 for Theta between 0 and 45 degrees in each octant.

WORD #13 - Magnetic Heading

SUBADDRESS: I04-13, I05-13

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	LSB (1/8,192)
15	Random 1's and 0's
16	Random 1's and 0's

REMARKS:

ACCURACY: 0.0035 radians RMS.

Positive sense is CW WRT magnetic north.

A to D converter resolution is equal to Tan Theta divided by 1024 for Theta between 0 and 45 degrees in each octant.

VII. CADC to INU

SUBADDRESS: C01, C02, C03

WORD #1 - CADC MODE WORD

SUBADDRESS: C01-01, C02-01, C03-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	Pressure Altitude Valid
2	Baro Ref Altitude Valid
3	TAS/AIR Density Ratio Valid
4	Mach Number Valid
5	Calibrated Airspeed Valid
6	Pressure Ratio Valid
7	True Angle of Attack Valid
8	True Freestream Air Temp Valid
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

1. Logic State 1 represents valid signal;

   Logic State 0 represents invalid signal.

AD-A084 036 AERONAUTICAL SYSTEMS DIV WRIGHT-PATTERSON AFB OH COMM--ETC F/G 17/7
CHARACTERISTIC FOR A MODERATE ACCURACY INERTIAL NAVIGATION SYST--ETC(U)
AUG 79

UNCLASSIFIED ASD/ENAC-77-1-REV-2 NL

4 OF 4
AD
A084036

END
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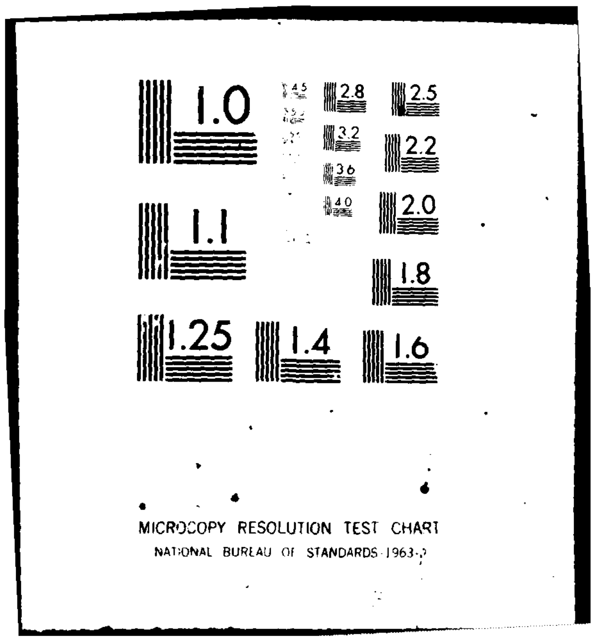

1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963

WORD #2 - Pressure Altitude

SUBADDRESS: C01-02, C02-02, C03-02

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (40,960 ft)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (2.5 feet)

Word #3 - Baro Reference Altitude

SUBADDRESS: C01-03, C02-03

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (40,960 feet)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (2.5 feet)

WORD #4 - True Airspeed

SUBADDRESS: C01-04, C02-04

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1,024 knots)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	LSB (0.125 knots)
16	Spare

Word #5 - Mach Number

SUBADDRESS: C01-05, C02-05

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (2 Mach No. Units)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	LSB (4/16,384 Mach No. Units)
16	Spare

Word #6 - Calibrated Airspeed

SUBADDRESS: C01-06, C02-06

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (512 knots)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	LSB (0.0625 knots)
16	Spare

Word #7 - True Angle of Attack

SUBADDRESS: C01-07, C02-07

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (90 Degrees)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB

REMARKS: 1. Signal relative to the aircraft velocity vector.

2. Angle of attack is positive when FRL is above velocity vector.

WORD #8 - Pressure Ratio (PS/PSO)

SUBADDRESS: C01-08, C02-08

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (PS/PSO = 1)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	LSB
16	Spare

Word #9 - Air Density Ratio

SUBADDRESS: C01-09, C02-09

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (RHO/RHOO = 1)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	LSB
16	Spare

Word #10 - True Freestream Air Temperature

SUBADDRESS: C01-10

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (256 Degree Kelvin)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	LSB (1/32 Degree Kelvin)
16	Spare

VIII. CC to INU

SUBADDRESS: F12

WORD #1 - CC/INU Mode Word

SUBADDRESS: F12-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	Spare
2	Filter Mode *
3	Spare
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

* Growth - use not currently defined.

WORDS #2, #3 - Strg Pt Coord. 7 (LAT)

SUBADDRESS: F12-02, F12-03

MSP / Word 2

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 3

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc/Min

Positive sense is north.

LSB Approx. 3.8 EXP-6

WORDS #4, #5 - Strg Pt Coord 7 (Long)

SUBADDRESS: F12-04, F12-05

MSP / Word 4

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 5

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

WORDS #6, #7 - Strng Pt Coord 8 (Lat)

SUBADDRESS: F12-06, F12-07

MSP / Word 6

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 7

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is north.

LSB Approx. 3.8 EXP-6

WORDS #8, #9 - Strg Pt Coord 8 (Long)

SUBADDRESS: F12-08, F12-09

MSP / Word 8

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 9

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

WORDS #10, #11 - Strg Pt Coord 9 (Lat)

SUBADDRESS: F12-10, F12-11

MSP / Word 10

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 11

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive Sense is north.

LSB Approx 3.8 EXP-6

WORDS #12, #13 - Strg Pt Coord 9 (Long)

SUBADDRESS: F12-12, F12-13

MSP / Word 12

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 13

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

WORDS #14, #15 - Mark Point 1 (Lat)

SUBADDRESS: F12-14, F12-15

MSP / Word 14 DATA FORMAT		LSP / Word 15 DATA FORMAT	
DATA BIT	**DESCRIPTION**	**DATA BIT**	**DESCRIPTION**
1	Sign Bit	1	*
2	MSB (1/2)	2	*
3	*	3	LSB (1/262,144)
4	*	4	Spare
5	*	5	Spare
6	*	6	Spare
7	*	7	Spare
8	*	8	Spare
9	*	9	Spare
10	*	10	Spare
11	*	11	Spare
12	*	12	Spare
13	*	13	Spare
14	*	14	Spare
15	*	15	Spare
16	*	16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is north.

LSB Approx. 3.8 EXP-6

WORDS #16, #17 - Mark Point 1 (Long)

SUBADDRESS: F12-16, F12-17

MSP / Word 16

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 17

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

WORDS #18, #19 - Mark Point 2 (Lat)

SUBADDRESS: F12-18, F12-19

MSP / Word 18

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 19

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is north.

LSB Approx. 3.8 EXP-6

WORDS #20, #21 - Mark Point 2 (Long)

SUBADDRESS: F12-20, F12-21

MSP / Word 20

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 21

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

WORDS #22, #23 - Mark Point 3 (Lat)

SUBADDRESS: F12-22, F12-23

MSP / Word 22

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 23

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Position sense is north.

LSB Approx. 3.8 EXP-6

WORDS #24, #25 - Mark Point 3 (Long)

SUBADDRESS: F12-24, F12-25

MSP / Word 24		LSP / Word 25	
DATA FORMAT		DATA FORMAT	
DATA BIT	DESCRIPTION	DATA BIT	DESCRIPTION
1	Sign Bit	1	*
2	MSB (1/2)	2	*
3	*	3	LSB (1/262,144)
4	*	4	Spare
5	*	5	Spare
6	*	6	Spare
7	*	7	Spare
8	*	8	Spare
9	*	9	Spare
10	*	10	Spare
11	*	11	Spare
12	*	12	Spare
13	*	13	Spare
14	*	14	Spare
15	*	15	Spare
16	*	16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is East.

LSB Approx. 3.8 EXP-6

SUBADDRESS: F16

<u>**WORD #1 - Mode Word**</u>

SUBADDRESS: F16-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	Spare
2	Filter Mode *
3	Spare
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
3	Spare
14	Spare
15	Spare
16	Spare

* Growth - use not currently defined.

WORDS #2, #3 - Strg Pt Coord 0 (Lat)

SUBADDRESS: F16-02, F16-03

MSP / Word 2

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 3

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is north.

LSB Approx. 3.8 EXP-6

WORDS #4, #5 - Strg Pt Coord 0 (Long)

SUBADDRESS: F16-04, F16-05

MSP / Word 4

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 5

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

WORDS #6, #7 - Strg Pt Coord 1 (Lat)

SUBADDRESS: F16-06, F16-07

MSP / Word 6

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 7

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is north

LSB Approx. 3.8 EXP-6

WORDS #8, #9 - Strg Pt Coord 1 (Long)

SUBADDRESS: F16-08, F16-09

MSP / Word 8		LSP / Word 9	
DATA FORMAT		DATA FORMAT	
DATA BIT	DESCRIPTION	DATA BIT	DESCRIPTION
1	Sign Bit	1	*
2	MSB (1/2)	2	*
3	*	3	LSB (1/262,144)
4	*	4	Spare
5	*	5	Spare
6	*	6	Spare
7	*	7	Spare
8	*	8	Spare
9	*	9	Spare
10	*	10	Spare
11	*	11	Spare
12	*	12	Spare
13	*	13	Spare
14	*	14	Spare
15	*	15	Spare
16	*	16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

WORDS #10, #11 - Strg Pt Coord 2 (Lat)

SUBADDRESS: F16-10, F16-11

MSP / Word 10

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 11

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is north.

LSB Approx. 3.8 EXP-6

WORDS #12, #13 - Strg Pt Coord 2 (Long)

SUBADDRESS: F16-12, F16-13

MSP / Word 12

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 13

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

WORDS #14, #15 - Strg Pt Coord 3 (Lat)

SUBADDRESS: F16-14, F16-15

MSP / Word 14

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 15

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is north.

LSB Approx. 3.8 EXP-6

WORDS #16, #17 - Strg Pt Coord 3 (Long)

SUBADDRESS: F16-16, F16-17

MSP / Word 16

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 17

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

WORDS #18, #19 - Strg Pt Coord 4 (Lat)

SUBADDRESS: F16-18, F16-19

MSP / Word 18

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 19

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is north.

LSB Approx. 3.8 EXP-6

WORDS # 20, #21 - Strg Pt Coord 4 (Long)

SUBADDRESS: F16-20, F16-21

MSP / Word 20

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 21

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

WORDS #22, #23 - Strg Pt Coord 5 (Lat)

SUBADDRESS: F16-22, F16-23

MSP / Word 22

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 23

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is North.

LSB Approx. 3.8 EXP-6

WORDS #24, #25 - Strg Pt Coord 5 (Long)

SUBADDRESS: F16-24, F16-25

MSP / Word 24		LSP / Word 25	
DATA FORMAT		DATA FORMAT	
DATA BIT	DESCRIPTION	DATA BIT	DESCRIPTION
1	Sign Bit	1	*
2	MSB (1/2)	2	*
3	*	3	LSB (1/262,144)
4	*	4	Spare
5	*	5	Spare
6	*	6	Spare
7	*	7	Spare
8	*	8	Spare
9	*	9	Spare
10	*	10	Spare
11	*	11	Spare
12	*	12	Spare
13	*	13	Spare
14	*	14	Spare
15	*	15	Spare
16	*	16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is East.

LSB Approx. 3.8 EXP-6

WORDS #26, #27 - Strg Pt Coord 6 (Lat)

SUBADDRESS: F16-26, F16-27

MSP / Word 26 DATA FORMAT		LSP / Word 27 DATA FORMAT	
DATA BIT	DESCRIPTION	DATA BIT	DESCRIPTION
1	Sign Bit	1	*
2	MSB (1/2)	2	*
3	*	3	LSB (1/262,144)
4	*	4	Spare
5	*	5	Spare
6	*	6	Spare
7	*	7	Spare
8	*	8	Spare
9	*	9	Spare
10	*	10	Spare
11	*	11	Spare
12	*	12	Spare
13	*	13	Spare
14	*	14	Spare
15	*	15	Spare
16	*	16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is north.

LSB Approx. 3.8 EXP-6

WORDS #28, #29 - Strg Pt Coord 6 (Long)

SUBADDRESS: F16-28, F16-29

MSP / Word 28

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	*

LSP / Word 29

DATA FORMAT

DATA BIT	DESCRIPTION
1	*
2	*
3	LSB (1/262,144)
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

REMARKS:

ACCURACY: 0.1 Arc Min

Positive sense is east.

LSB Approx. 3.8 EXP-6

SUBADDRESS: F17

WORD #1 - Mode Word

SUBADDRESS: F17-01

DATA FORMAT

DATA BIT	DESCRIPTION
1	Spare
2	Filter Mode *
3	Spare
4	Spare
5	Spare
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare
16	Spare

* Growth - use not currently defined.

WORD #2 - Steering Error

SUBADDRESS: F17-02

DATA FORMAT

DATA BIT	DESCRIPTION
1	Sign Bit
2	MSB (1/2)
3	*
4	*
5	*
6	*
7	*
8	*
9	*
10	*
11	*
12	*
13	*
14	*
15	*
16	LSB (1/32,768)

REMARKS: LSB Approx 6 Arc Sec

ADDENDUM A

F-16

REQUIREMENTS

1.0 SCOPE. The following addendum modifies the basic specification such that it becomes compatible with the F-16 application. Requirements in this addendum are in addition to the basic specification.

2.0 APPLICABLE DOCUMENTS.

2.1 Government Documents. The following documents shown form a part of this specification to the extent specified herein. In the event of a conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered as superseding requirements:

STANDARDS

Military

MIL-STD-454D 31 August 1973	Standard General Requirements for Electronic Equipment
MIL-STD-461A 1 August 1968	Electromagnetic Interference Characteristic, Requirements for Equipment
MIL-STD-462 31 July 1967	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-704A(3) 11 April 1973	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-781B 15 November 1967	Reliability Tests; Exponential Distribution
MIL-STD-1553 30 August 1973	Aircraft Internal Time Division Multiplex Data Bus

SPECIFICATIONS

Military

MIL-B-5087 31 August 1970	Bonding, Electrical, and Lighting Protection, for Aerospace Systems
MS25271 19 February 1970	Relay, 10 amp, 4 Pdt, Class B8, sealed, with Solder Hooks

2.2 Non-Government Documents. The following documents form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this

specification shall take precedence over all referenced documents. All documents shall be of the latest revisions.

SPECIFICATIONS.

General Dynamics

16ZE012 (B) 6 November 1975	Critical Item Development Specification for the F-16 Fire Control/Navigation Panel
16PP243 27 July 1976	Interface Control Document for the F-16 Inertial Navigation Unit & Fire Control Navigation Panel

3.0 REQUIREMENTS

3.1 Item Description. The Inertial Navigation Set, herein addressed as INS, shall be a self-contained navigator capable of fulfilling the navigation requirements of and capable of installation in a lightweight, high speed, air superiority fighter, and shall be supportable in primitive, forward operating base areas where skilled maintenance technicians are unavailable. The INS shall be capable of interfacing with the aircraft displays, computers, radar and other avionics. The INS shall be comprised of two basic parts:

a. An Inertial Navigation Unit (INU).

b. An INU Battery/Mount (INBU). The battery and mount shall be two separate LRUs.

The INS shall be of the same configuration for both the one- and two-place F-16s.

3.1.1 Item Diagram. In accordance with the basic specification.

3.1.2 Interface Definition. Figure A-1 delineates the information flow, under normal conditions, between the various elements of the F-16 avionics suite. Each arrow represents a message set to be transferred between elements. The INU message sets are defined in Figure A-2. Note that data transfers from the INS to avionics other than Fire Control Computer (which is also the prime bus controller) are by means of terminal-to-terminal transfers as defined in 16PP243, paragraph 3.2.3.3.8.3.

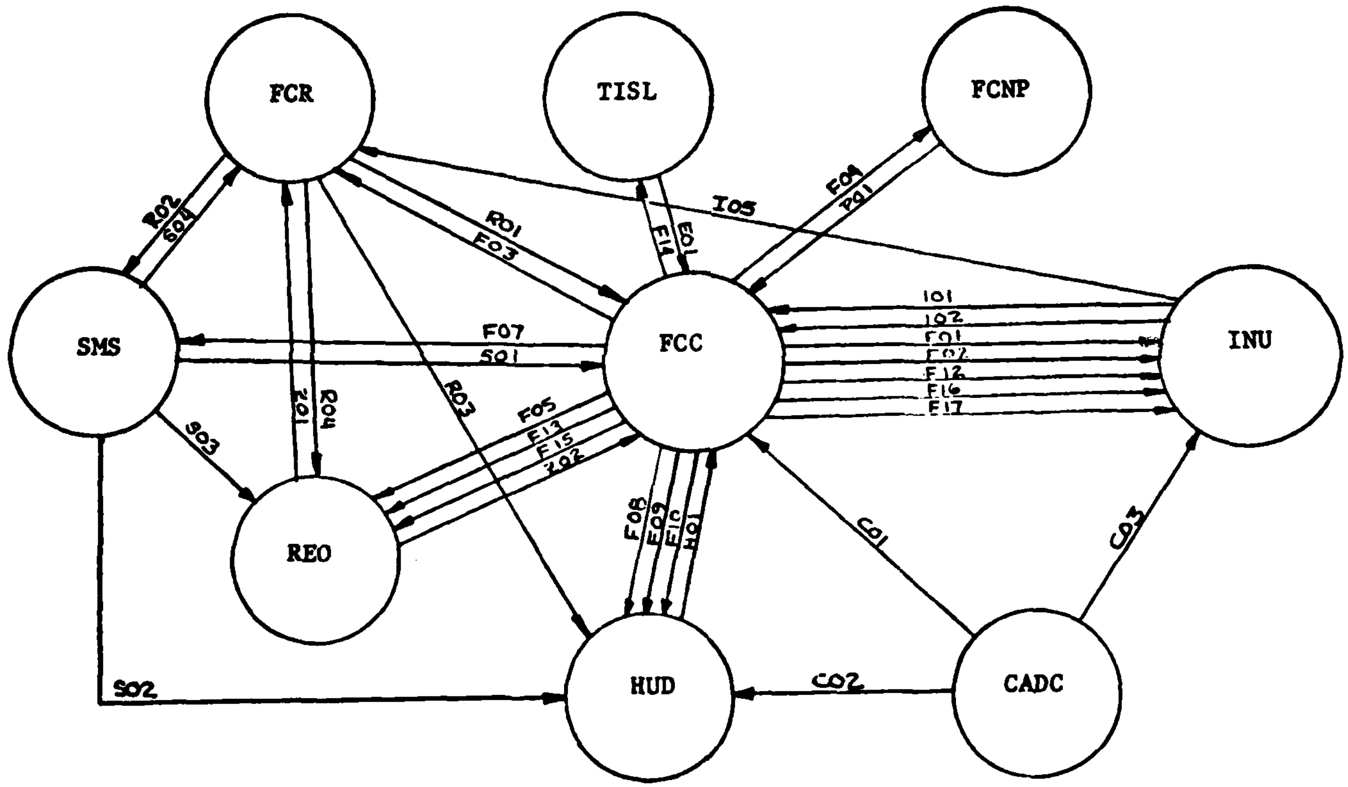
Figure A-3 delineates the information flow when the INU bus control function is activated.

Table A-1 illustrates the F-16 analog and discrete signal interface requirements.

FIGURE A1

F-16 MULTIPLEX DATA BUS FUNCTIONAL BLOCK DIAGRAM

(UNDER FCC BUS CONTROL)

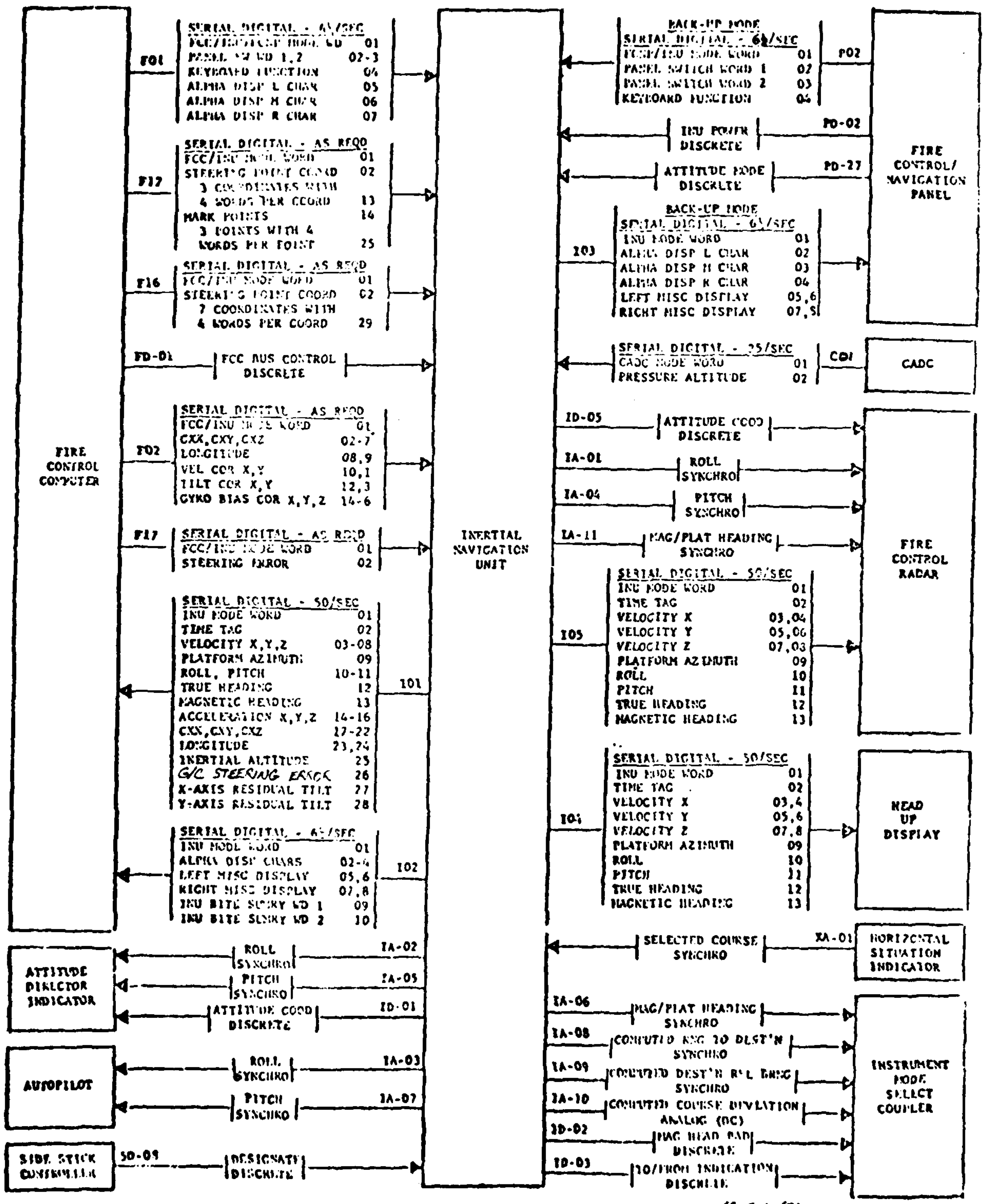


FCR - FIRE CONTROL RADAR
SMS - STORES MANAGEMENT SET
REO - RADAR E/O DISPLAY

TISL - TARGET IDENT SET, LASAR
FCC - FIRE CONTROL COMPUTER
HUD - HEAD-UP DISPLAY

FCNP - FIRE CONTROL/NAVIGATIONAL PANEL
INU - INERTIAL NAVIGATION UNIT
CADC - CENTRAL AIR DATA COMPUTER

INERTIAL NAVIGATION UNIT ELECTRICAL SIGNAL INTERFACE

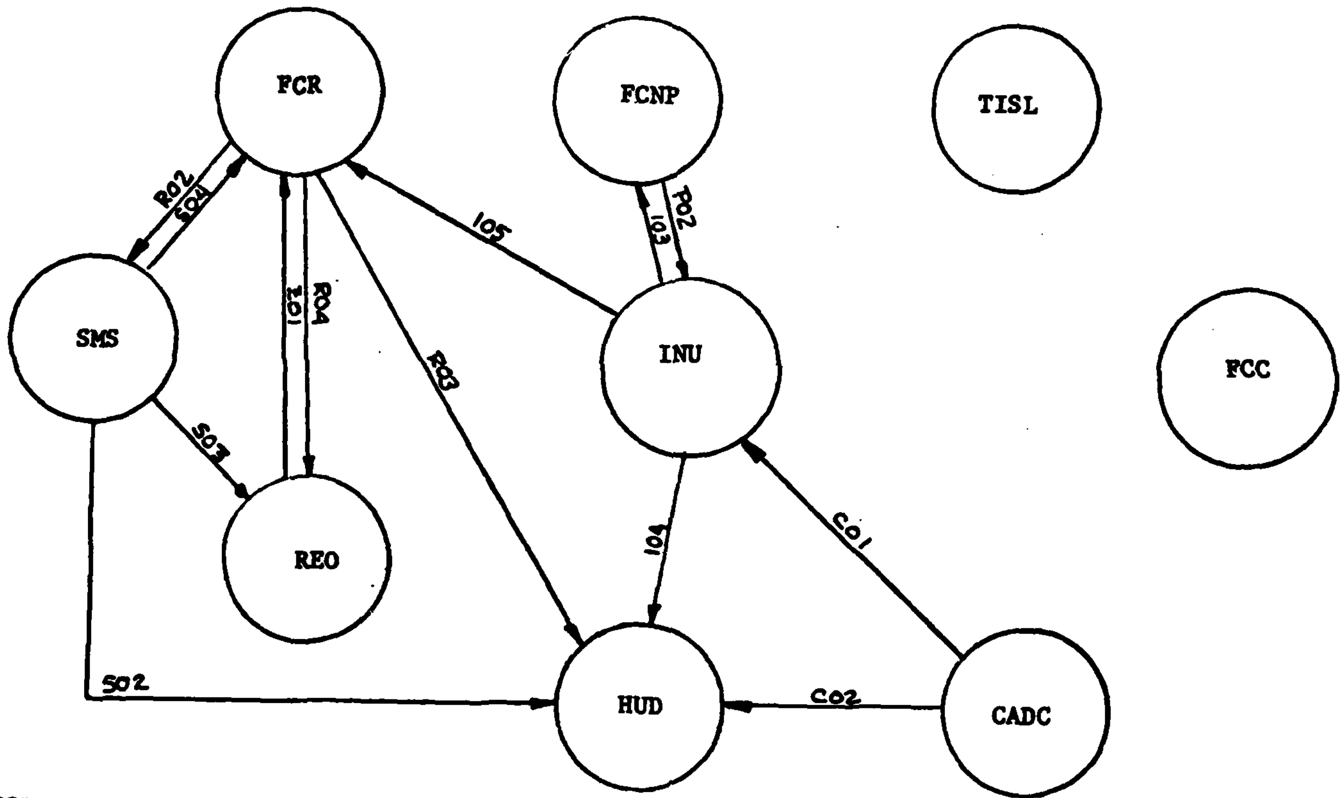


13 July '76

FIGURE A2

FIGURE A3

F-16 MULTIPLEX DATA BUS FUNCTIONAL BLOCK DIAGRAM
(UNDER INU BUS CONTROL)



FCR - FIRE CONTROL RADAR
SMS - STORES MANAGEMENT SET
REO - RADAR E/O DISPLAY

FCNP - FIRE CONTROL/NAV PANEL
INU - INERTIAL NAVIGATION UNIT
HUD - HEAD-UP DISPLAY

TISL - TARGET IDENT SET, LASAR
FCC - FIRE CONTROL COMPUTER
CADC - CONTROL AIR DATA COMPUTER

TABLE A1 - F-16 PECULIAR ANALOG/DISCRETE INTERFACE

SIGNAL	TO	REMARKS	RANGE	ACCURACY	POSITIVE DIRECTION	LOAD	PHASE SHIFT
Roll (Single Output)	FCR	Synchro Buffered	0° to 360°	0.1° RMS	Right Bank	5K Balanced ±5%	+14 ±4 Deg. Lead
Pitch (Single Output)	FCR	Synchro Buffered	±90°	0.1° RMSq	Nose Up	5K Balanced ±5%	+14 ±4 Deg. Lead
Attitude Good	FCR	Discrete	Open or A/C +28 VDC	-	+28 VDC = True	10K	
Computed Range to Dest.	Instr. Mode Coupler (1 or 2 HSIs)	3 Synchros	0 to 999	0.5 NM RMS	Range Increase	1 or 2 Sets of 3 CRC-8-A-1 (10+J45) Zso	10±6 Deg. Lead
Computed Destination Relative Bearing	Instr. Mode Coupler (1 or 2 HSIs)	Synchro	0° to 360°	±0.5° MAX	CW Inc. Course	1 or 2 AY500-5 (222 +J470)	±1 Deg.
Mag. Heading (Platform Heading in ATT Mode)	Instr. Mode Coupler (1 or 2 HSIs & TACAN), FCR	Synchro	0° to 360°	±0.5°	Inc. Head WRT Mag. North	Note 1	+14 ±14 Deg. Lead
Mag. Heading Bad	Instr. Mode Coupler	Discrete	Open or A/C +28 VDC		+28 VDC = True	720 A/P Relay	-

NOTE 1 - Magnetic heading load is an equivalent delta with a minimum impedance of 167 ohms on each leg including a parallel load of 22 ±15% ohms resistance in series with 2.47 ±11% microfarads capacitance.

TABLE A1 - F-16 PECULIAR ANALOG/DISCRETE INTERFACE (Cont'd)

SIGNAL	TO	REMARKS	RANGE	ACCURACY	POSITIVE DIRECTION	LOAD	PHASE SHIFT
Computed Course Deviation	Instr. Mode Coupler	Analog (DC)	±10°	±10 AMP MAX	Bar to Right	1000 Ω each output	
To-From	Instr. Mode Coupler (1 or 2 HSIs)	Discrete	0 ±5 or ±325 ±100 AMP per HSI	-	To (+)	200 for 1 100 for 2 ±15%	

INPUT SIGNAL	REMARKS	UNITS	RANGE REQD	POSITIVE DIRECTION
Selected Course	3 Wire Synchro	--	0 to 360°	CW WRT North
Designate On	Discrete (From Sidestick Controller)	--	+28 VDC = TRUE 0 VDC = FALSE	--

The F-16 message formats for the serial digital bus and analog signal characteristics are specified in 16PP243.

3.1.2.1 Bus Control. In accordance with 16PP243, paragraph 3.2.3.4.3 and 3.2.3.5.

3.1.2.1.1 Data Bus Redundancy. In accordance with 16PP243, paragraphs 3.2.3.4 and 3.2.3.5.2.

3.1.2.1.2 Bus Address. In accordance with the basic specification.

3.1.2.1.3 Status Word Bit Assignment. In accordance with 16PP243 paragraph 3.2.3.3.7.3 except subsection 3.2.3.3.7.3.9 will not be implemented.

3.1.2.1.4 Mode Commands. A value of all ones in the subaddress/mode field shall indicate that the command word is a function command and that data is not to be transmitted or received.

The controller shall issue a dedicated function command to the subsystem. The subsystem shall, after execution of the action required by the function word, transmit a status word back to the controller.

3.1.2.1.5 Input/Output (I/O). In accordance with the basic specification.

3.1.2.1.6 Multiplex Data Bus Output/Input Characteristics. This paragraph is a constraint on paragraph 60.4.2.5.3.1 of the basic specification. The output level of the INS data bus transmitter shall be compatible with the F-16 specified receivers, i.e., the driver output level shall not cause the input levels of any terminal's receiver to exceed the receiver level specified in 16PP243, paragraph 3.2.3.3.10.4.1. The output level will be in accordance with 16PP243, paragraph 3.2.3.3.10.3.2.

3.2 Characteristics.

3.2.1 Performance. In accordance with the basic specification.

3.2.1.1 Position Accuracy. In accordance with the basic specification.

3.2.1.2 Velocity Accuracy. In accordance with the basic specification.

3.2.1.3 Reaction Times. In accordance with the basic specification.

3.2.1.4 Attitude Accuracy. In accordance with the basic specification.

3.2.1.5 Latitude Range/Vehicle Motion During Alignment. In accordance with the basic specification.

3.2.1.6 Performance Certification. In accordance with the basic specification.

3.2.1.7 INS Functions. In accordance with the basic specification.

3.2.1.8 Selectable Modes. In accordance with the basic specification.

3.2.1.9 Data Output. In accordance with the basic specification.

3.2.2 Physical Characteristic. In accordance with the basic specification.

3.2.2.1 Size. In accordance with the basic specification.

3.2.2.2 Electrical Interface.

Figure A-4 illustrates the F-16 INS signals by pin assignment (INU and battery only).

3.2.2.3 Electrical Power. The INU shall give specified performance from the following power sources with characteristics as specified in MIL-STD-704A, having limits as specified herein.

(1) AC Power. 115/200 volts, 400 cps, 3∅

a. Operating Voltage Limits. In accordance with Category B, Table I of MIL-STD-704A.

b. Power Factor Limits. In accordance with Category B, Figure 12, MIL-STD-704A.

(2) 28 Volts, DC, 600 Watts Maximum. Operating voltage limit in accordance with Category B, Table II of MIL-STD-704A.

(3) Voltage Protection.

a. AC Voltage. The INU shall not be damaged by AC voltages as specified between Limit 1 and Limit 4, Figure 3, of MIL-STD-704A. The equipment shall operate normally when supplied power between Limits 2 and 3, Figure 3, of MIL-STD-704A.

b. DC Voltage. The INS shall not be damaged when supplied with DC voltage between Limit 1 and Limit 4, Figure 9, MIL-STD-704A.

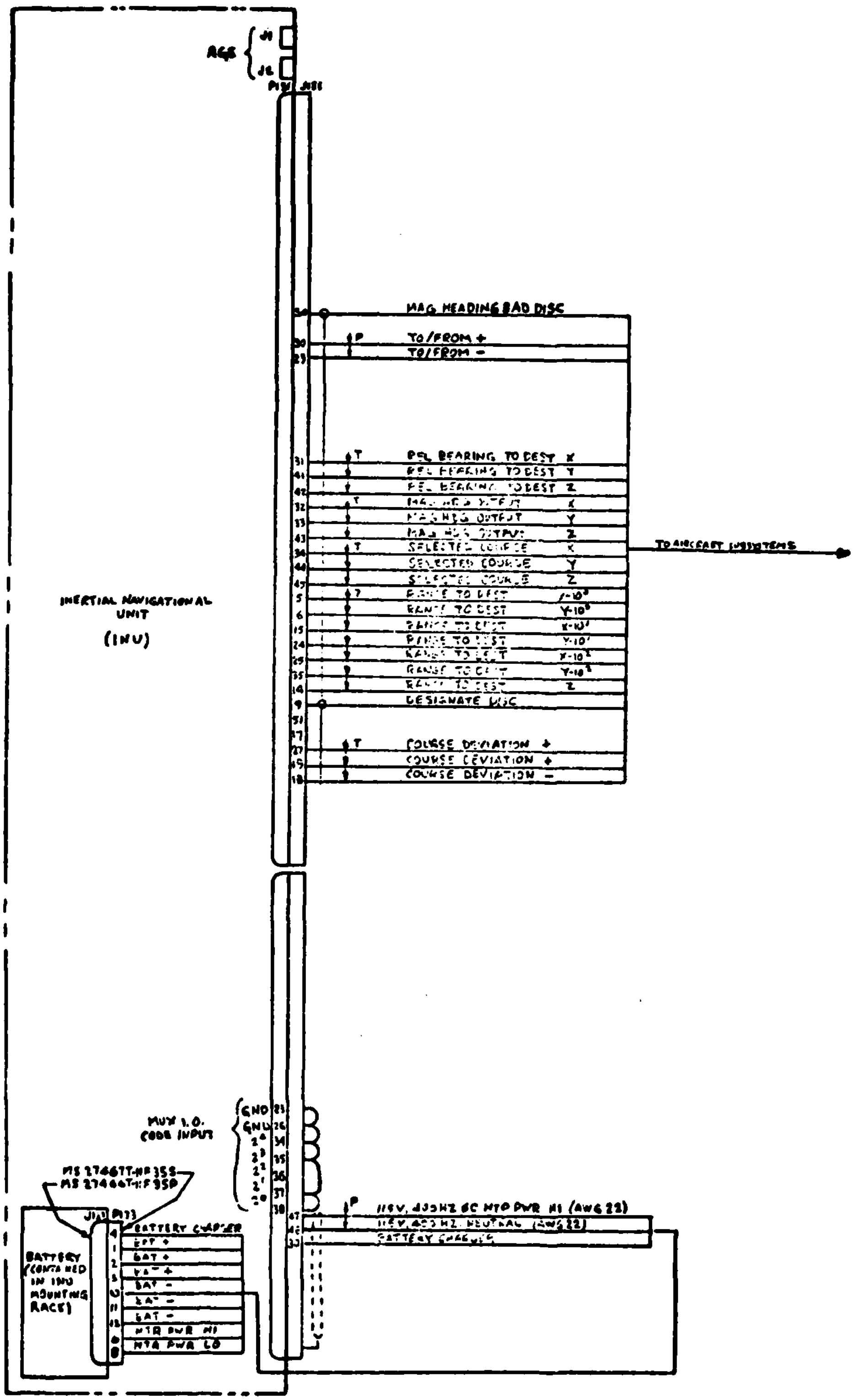


Figure A4 - Electrical Interface

c. Voltage Loss. The INS shall not sustain damage due to a loss of one (1) phase or one (1) voltage and shall comply with the requirements of abnormal electric system operation as specified in MIL-STD-704A.

Power requirements of the INS shall be as follows:

	STARTING	RUNNING	POWER FACTOR
115V 400 Hz 1 Phase A Prime Power	340VA	280VA	0.8 Min.
115V 400 Hz 1 Phase B Heater Power	710VA (1)	70VA (2)	0.7 Min. (3)
115V 400 Hz 1 Phase C Heater Power	770VA (1)	70VA (2)	0.7 Min. (3)
26V 400 Hz 1 Ø (supplied through transformer from Prime Power Phase)	40VA	35VA	0.5 Min.

(1) Includes full platform and battery heater power (reduce phase C to 530VA if no battery heater).

(2) Includes platform heater power at +35 F cooling air (if battery heater is included, power is at +85 F ambiént air temperature).

(3) Power Factor is 0.95 minimum for starting VA.

d. Operation through Power Interrupts. When supplied with MIL-STD-704A, Category B power, the INS shall be capable of maintaining operation as specified herein through power interruptions of up to 10 seconds.

3.2.3 Reliability. The specified MTBF (θ_o) to be demonstrated during the preproduction phase shall be 150 hours. The specified MTBF (θ_o) to be demonstrated during production shall be 740 hours.

3.2.4 Maintainability. In accordance with the basic specification.

3.2.4.1 Design. In accordance with the basic specification.

3.2.4.1.1 Calibration Interval. In accordance with the basic specification.

3.2.4.1.2 Maintainability Definitions. In accordance with the basic specification.

3.2.4.2 Repair. In accordance with the basic specification.

3.2.4.2.1 Organizational-Level Maintainability Requirements. In accordance with the basic specification.

3.2.4.2.1.1 Equipment Handling. In accordance with the basic specification.

3.2.4.2.1.2 Adjustments. In accordance with the basic specification.

3.2.4.2.1.3 Boresighting. In accordance with the basic specification.

3.2.4.2.1.4 INBU Mount. The following is in addition to the requirements established in the basic specification. The INBU consists of two LRU's:

a. INU Mount which will be secured to the aluminum airplane structure and have boresight and quick install/removal provisions for the INU.

b. INU Battery which is installed in the mount via quick install/removal provisions and mates electrically with the INU. (See Figure A-4a).

3.2.4.2.2 Intermediate-Level Maintainability Requirements. In accordance with the basic specification.

3.2.4.2.2.1 Packaging. In accordance with the basic specification.

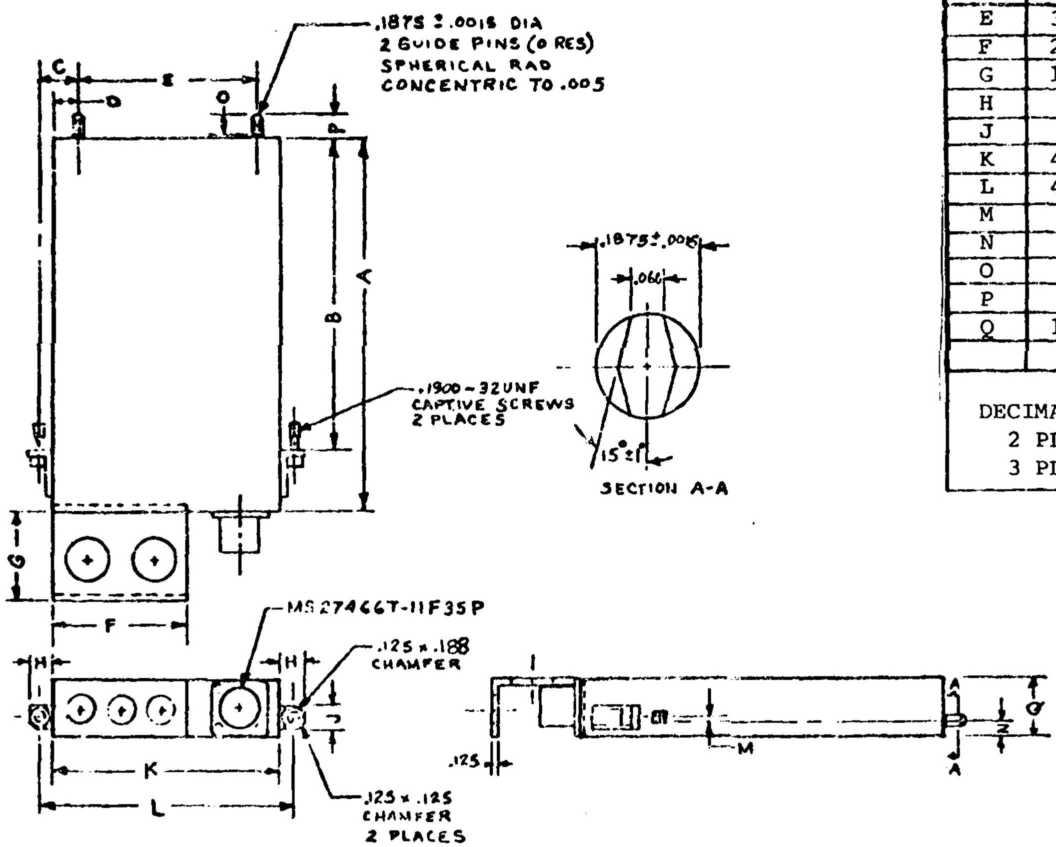
3.2.4.2.2.2 Adjustments. In accordance with the basic specification.

3.2.4.2.2.3 Reversibility Restrictions. In accordance with the basic specification.

3.2.4.2.2.4 Accessibility. In accordance with the basic specification.

3.2.4.3 Built-In-Test (BIT) Function. The following is in addition to the requirements established in the basic specification.

The results of these tests shall be available for display on the FCNP and appear on the NAV status word and the attitude Good and Mag Heading Bad discretes.



BATTERY

DIMENSIONS	(INCHES)	
SYM	VALUE	NOTES
A	6.69	MAX
B	5.64	
C	.709	+.001
D	.320	±.020
E	3.300	±.001
F	2.50	
G	1.53	
H	.555	+.000-.010
J	.437	
K	4.01	MAX
L	4.718	±.001
M	.080	±.001
N	.250	
O	.400	
P	.437	
Q	1.03	MAX

DECIMAL TOL
2 PLACE ±.03
3 PLACE ±.010

Figure A4a

3.2.4.3.1 Failure Detection Function. In accordance with the basic specification.

3.2.4.3.1.1 Failure Detection Performance. The basic specification requirement is modified below to reflect the F-16 design goals.

The self-test shall be capable of detecting a minimum of 95 percent of all malfunctions and out-of-tolerance conditions, with a design goal of 99 percent. Self-test, supplemented as necessary with BIT, shall be capable of isolation of a faulty LRU, a minimum of 95 percent of the detected malfunctions and out of tolerance conditions, with a design goal of 99 percent. Self-test false alarms shall not exceed 1 percent of all malfunction indications.

3.2.4.3.2 Failure Location Function. In accordance with the basic specification.

3.2.4.3.2.1 Organizational Level. In accordance with the basic specification.

3.2.4.3.2.2 Intermediate Level. In accordance with the basic specification.

3.2.4.3.2.3 Failure Location Performance. The basic specification is modified to include the following F-16 constraints and goals.

Each LRU shall contain sufficient test points in external test connectors and normal interface connectors to allow a positive fault isolation to an SRU for a minimum of 97 percent of all failures.

SRU maintenance shall consist of all maintenance operations necessary for complete repair and/or overhaul of the SRUs. To facilitate these maintenance operations utilizing Automatic Test Equipment (ATE), each SRU shall contain the real test access points necessary to provide the following fault detection and isolation capability:

a. The minimum acceptable level of fault detection shall be 97% of all possible functional failures with a design goal of 99%.

b. Fault isolation to a single circuit element (Component) in 85% of the detected faults.

c. Fault isolation to two circuit elements in 85% to 95% of the detected faults.

d. Fault isolation to three circuit elements in 95% to 99% of the detected faults.

Additionally, the SRUs shall contain sufficient test access points for circuit initialization when required during automatic testing. The necessity for additional circuit elements on the SRUs to meet the requirements of this paragraph shall not be considered a restraining factor.

Testability design shall be verified by use of analytical/statistical data prepared either manually or by making use of available computer aided test analysis program such as the Navy/Air Force LASAR Program.

3.2.4.4 Preventative Maintenance. The battery may require recharging after extended periods of non-use.

3.2.5 Environmental Conditions. In accordance with the basic specification.

3.2.5.1 Temperature. In accordance with the basic specification.

3.2.5.2 Altitude. In accordance with the basic specification.

3.2.5.3 Vibration. In accordance with the basic specification.

3.2.5.3.1 Gun Fire Vibration. In accordance with the basic specification.

3.2.5.4 Rain. In accordance with the basic specification.

3.2.5.5 Solar Radiation. In accordance with the basic specification.

3.2.5.6 Acoustic Noise. In accordance with the basic specification.

3.2.5.7 Flight Environment. In accordance with the basic specification.

3.2.5.8 Fluids. In accordance with the basic specification.

3.2.6 Transportability. In accordance with the basic specification.

3.3 Design and Construction. In accordance with the basic specification.

3.3.1 Useful Life. In accordance with the basic specification.

3.3.2 Operational Service Life. In accordance with the basic specification.

3.3.2.1 Storage. In accordance with the basic specification.

3.3.3 Design Loads. In accordance with the basic specification.

3.3.3.1 Normal Operating Load Factors. In accordance with the basic specification.

3.3.3.2 Limit Load Factors. In accordance with the basic specification.

3.3.3.3 Ultimate Load Factors. In accordance with the basic specification.

3.3.4 Thermal Design. In accordance with the basic specification.

3.3.4.1 Cooling Air Conditions. Unless otherwise indicated, force-cooled equipment shall meet the performance requirements of this specification when exposed to the environmental conditions of 3.2.5 and supplied with cooling air having the following characteristics.

a. Supply Air Temperature:

(1) Minimum:

(a) Preflight and Ground Maintenance:

Minus 40°C

(b) Aircraft ECS, Flight and Ground:

Minus 18°C - Normal

Minus 54°C - Abnormal

(2) **Maximum:**

(a) **Ground Operation, including Start Up:**

Plus 49°C

(b) **In-flight, All Altitudes:**

Plus 27°C - Normal

Plus 49°C - Abnormal

Degraded performance will be allowed during exposure to abnormal supply air temperatures outside the normal range, but the equipment shall sustain no permanent damage as a result of the exposure. The equipment shall regain full performance capability as soon as normal supply air temperature conditions are restored.

3.3.4.2 Cooling Air Flow. The INS shall meet the performance and reliability requirements of this specification when exposed to the environmental conditions of 3.2.5 of the basic specification and supplied with cooling air in accordance with Figure A-5.

3.3.4.3 Resistance to Overcooling. The INS shall meet the performance and reliability requirements of this specification when receiving cooling air-flow rates up to 300 percent of the rate shown in Figure A-5 for a supply air temperature of 27°C. These flow rates may occur at any supply air temperature within the ranges specified in 3.3.4.1 and at any combination of surrounding conditions defined in 3.2.5 of the basic specification. Exposure to these conditions shall cause neither permanent damage nor degraded performance except as allowed in 3.3.4.1.

3.3.4.4 Cooling Air Pressure Loss (Pressurization). Equipment cooling air pressure loss is defined as the difference between the total pressure of the cooling air entering the equipment and the pressure of the air surrounding the equipment. The combined total pressure loss for the INU and mount shall not exceed the values indicated below for each of the three specified conditions while operating in the maximum heat dissipating mode.

	CONDITION A	CONDITION B	CONDITION C
Max allowable total pressure loss, inches H_2O	6.0	20.4	34.1
Surrounding air pressure, psia	14.7	1.04	14.7
Cooling air supply temperature, °C	27	0	49
Surrounding air temperature, °C	71	71	71
Cooling air flow rate	Per 3.3.4 of this addendum		

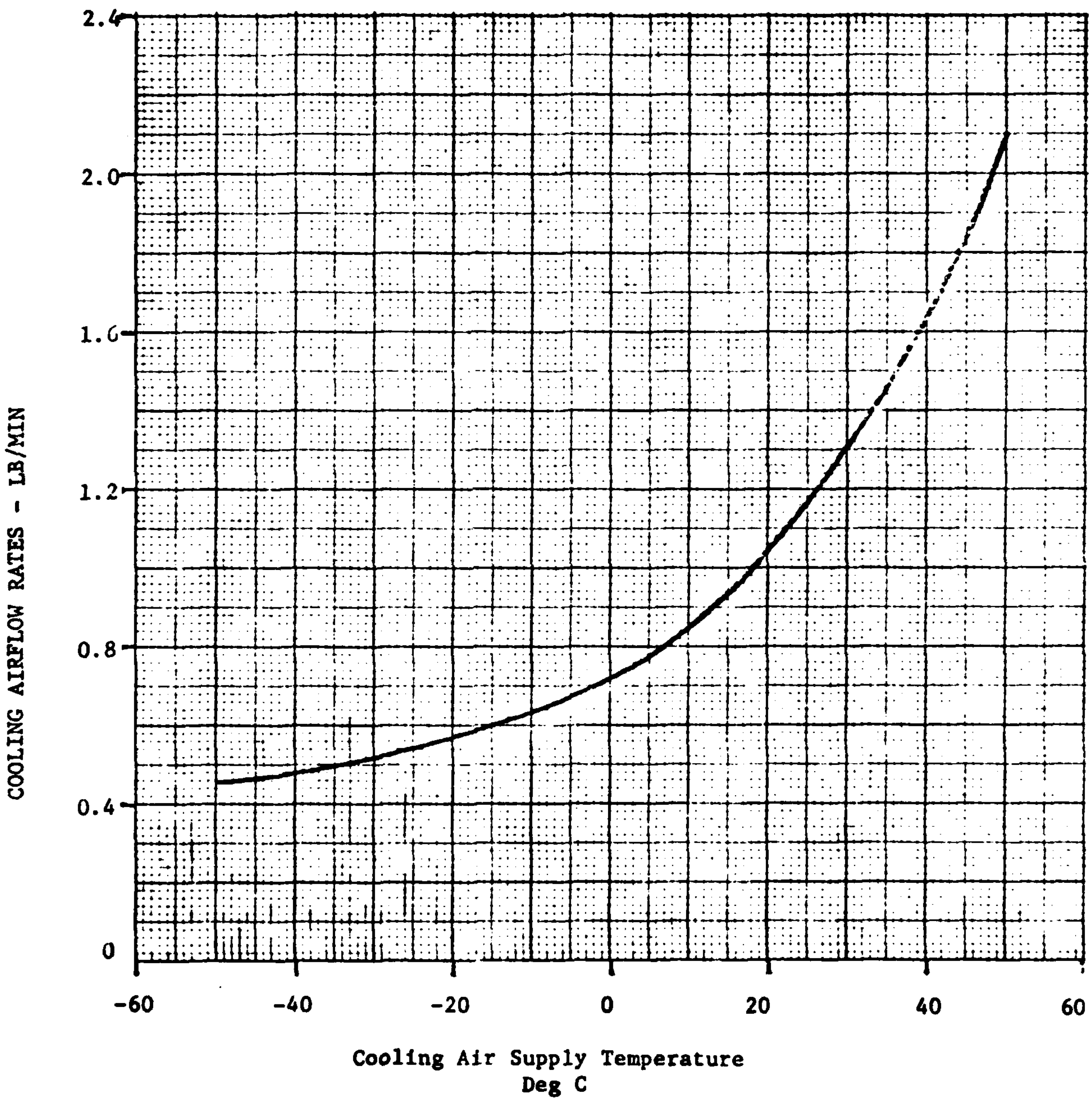


FIGURE A5 - COOLING AIRFLOW REQUIREMENTS FOR INU AND MOUNT

For interchangeability in the aircraft, the total pressure loss of deliverable INU's and mounts shall not vary more than 10 percent from nominal acceptance test values.

3.3.4.5 Cooling Air Connectors. In accordance with basic specification.

3.3.5 Electromagnetic Interference (EMI). The INS shall meet the following requirements:

3.3.5.1 Bonding. In accordance with the basic specification.

3.3.5.2 General. The INS shall meet MIL-STD-461 and shall be tested in accordance with MIL-STD-462. The EMC plan in accordance with MIL-STD-461 shall be the controlling document for EMIC design.

3.3.5.3 EMI Requirements. The generation of and susceptibility to electromagnetic interference shall be controlled in all units of electrical/electronic equipment. These units shall meet MIL-STD-461 requirements as specified and/or modified below. The specific requirements and modification of MIL-STD-461 are as follows:

TEST METHOD

CE01 (3)	CS02	RS02 (2)
CE03 (1)	CS06	RS03
CS01	RE02	

The numbers in parentheses above refer to the notes which follow:

NOTES: (1) Change frequency range to .10 MHz to 50 MHz. Data shall be collected from .014 MHz to .10 MHz for information purposes only.

(2) The procedures and limits of Method RS02 (a) and (b) shall apply except that the voltage E of Part (b) shall be 400 volts across 5 ohms.

(3) This test shall be performed for data purposes only.

In addition, the following EMC requirements shall apply:

a. Transient (Impulse) Susceptibility. No change in indications, malfunction, or degradation of performance shall

be indicated in any equipment and/or its load when exposed to an impulse type electromagentic field generated by a type MS25271 relay (or an acceptable equivalent) when wired for continuous operation with a switch in series with the positive side of the line from a 28 volt DC power source as shown in Figures A-6 and A-7. No suppression components (shielding, diodes, etc.) shall be attached to the relay or its wiring. The unshielded positive lead leaving the switch shall be laid over three sides of the test sample and then connected to the relay. The unshielded return lead from the relay shall be taped to and in parallel with input power leads, signal leads, and interconnecting leads. The total length of each external wiring harness paralleled with the relay circuit shall not be less than 60 inches. The 28 volt input shall be reversed and the transient repeated.

b. Magnetic Susceptibility. The INS shall operate without degradation of performance when the INU (or the unit containing the inertial reference) is subjected to a magnetic field which has a magnitude of 4 gauss at the unit and a gradient of 20 gauss per foot.

3.3.5.4 Associated Criteria For EMI Control. All electrical and electronic, including mounting fixtures, shall be electrically bonded to airplane structure. The DC resistance of the bond from equipment chassis to airplane structure shall be 0.0025 ohms or less as required in MIL-B-5087; Class R bonding jumpers may be used across any necessary vibration isolators.

3.3.6 Nameplates and Product Marking. In accordance with the basic specification.

3.3.7 Workmanship. In accordance with the basic specification.

3.3.8 Safety. In accordance with the basic specification.

3.3.8.1 Safety Markings. In accordance with the basic specification.

3.3.9 Human Engineering. In accordance with the basic specification.

3.3.10 Elapsed Time Meter. In accordance with the basic specification.

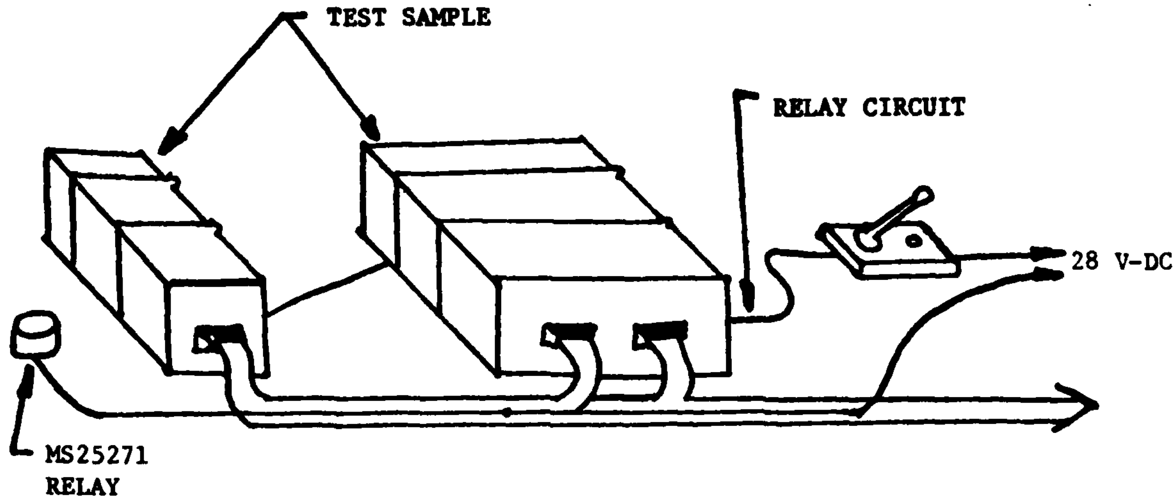


FIGURE A6 TRANSIENT SUSCEPTIBILITY TEST

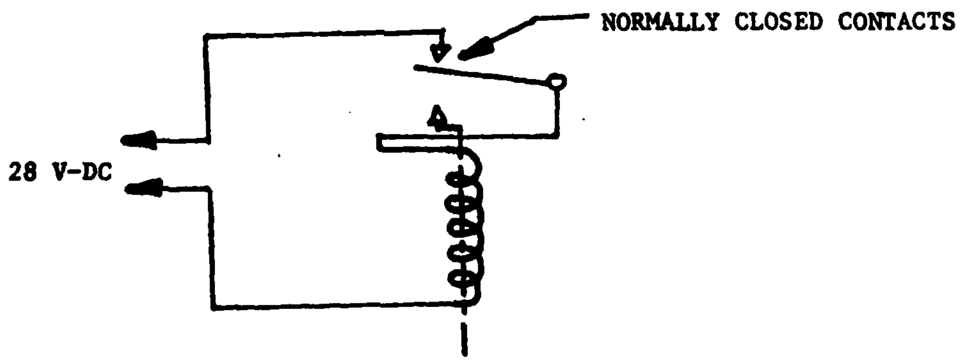


FIGURE A7 RELAY WIRING DETAILS

3.3.11 Connectors. In accordance with the basic specification.

3.3.12 Parts, Materials and Processes. In accordance with the basic specification.

3.3.12.1 Microcircuits. In accordance with the basic specification.

3.3.12.2 Semiconductors. In accordance with the basic specification.

3.3.12.3 Passive Devices. In accordance with the basic specification.

3.3.12.4 Non-Standard Parts. In accordance with the basic specification.

3.3.13 Finishes and Colors. In accordance with the basic specification.

3.3.14 Handle and Grasp Areas. In accordance with the basic specification.

3.3.15 Environmental Protection. In accordance with the basic specification.

3.3.15.1 Toxicity. In accordance with the basic specification.

3.3.15.2 High Voltage. In accordance with the basic specification.

3.3.16. Hazard Protection. In accordance with the basic specification.

3.3.17 Switching Transients. In accordance with the basic specification.

3.3.18 Overload Protection. In accordance with the basic specification.

3.3.19 Modular Design. In accordance with the basic specification.

3.3.20 Personnel and Training. In accordance with the basic specification.

3.3.21 Computer Program (Software). The computer programs for the system shall be divided into two groups:

a. Operational (Flight) Program

b. Maintenance Program

3.3.21.1 Operational Program. The operational program shall be written in a logical manner in accordance with the normal moding sequence of the system such as:

a. Course Alignment
b. Fine Align
c. Calibration
d. Navigation
e. Bus Control
f. Fixtaking
g. Self-Tests

3.3.21.2 Maintenance Program. The maintenance program shall be provided for shop calibration of inertial components and trouble-shooting as appropriate.

3.4 Logistics.

3.4.1 Maintenance. The policy of three levels of maintenance (organizational, intermediate, and depot) will be employed for support of the equipment. The concept requires rapid accessibility to all line replaceable units (LRUs) with the LRUs designed for fast removal and replacement, and on-board capability for equipment checkout and LRU isolation. The intermediate level maintenance will consist primarily of repairing LRUs returned from the flight line. This will be accomplished by removing and replacing shop replaceable assemblies, subassemblies, or units. The equipment shall be designed for, and shall be equipped with, connectors at accessible locations for test equipment as may be required to perform checkout of the equipment without repairing its removal. External test points shall be incorporated into the equipment for connection of the required test equipment during bench testing, calibration and trouble-shooting.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 General. In accordance with the basic specification.

4.1.1 Responsibility for Tests. In accordance with the basic specification.

4.1.2 Test Samples. In accordance with the basic specification.

4.1.3 Standard Conditions. In accordance with the basic specification.

4.1.4 Test Apparatus Accuracy. In accordance with the basic specification.

4.1.5 Failure Criteria. In accordance with the basic specification.

4.1.6 Test Sample Refurbishment. In accordance with the basic specification.

4.1.7 Functional Tests. In accordance with the basic specification.

4.2 Test Classification. In accordance with the basic specification.

4.2.1 Examination of Product. In accordance with the basic specification.

4.2.2 Performance Certification Test. In accordance with the basic specification.

4.2.3 Acceptance Test. In accordance with the basic specification.

4.2.3.1 Examination of Product. In accordance with the basic specification.

4.2.3.2 Performance/Functional Tests. In accordance with the basic specification.

4.2.3.3 Rejection and Retest. In accordance with the basic specification.

4.2.3.4 Test Conditions. In accordance with the basic specifications.

TABLE A-2

QUALITY ASSURANCE CROSS REFERENCE TABLE

SECTION 3.0

REQUIREMENT	REFERENCE	LABORATORY	AIRCRAFT
3.1	Item Description	4.2.1	-
3.1.1	Item Diagram	4.2.1	-
3.1.2	Interface Definition	4.2.3.2	-
3.1.2.1	Bus Control	4.2.3.2	-
3.1.2.1.1	Data Bus Redundancy	4.2.3.2	-
3.1.2.1.2	Bus Address	4.2.3.2	-
3.1.2.1.3	Status Word BIT Assignment	4.2.3.2	-
3.1.2.1.4	Mode Commands	4.2.3.2	-
3.1.2.1.5	Input/Output (I/O)	4.2.3.2	-
3.1.2.1.6	Multiplex Data Bus Output/ Input Characteristics	4.2.3.2	-
3.2	Characteristics	-	-
3.2.1	Performance	4.2.3.2	50.4.2
3.2.1.1	Position Accuracy	4.2.3.2	50.4.2
3.2.1.2	Velocity Accuracy	4.2.3.2	50.4.2
3.2.1.3	Reaction Times	4.2.3.2	50.4.2
3.2.1.4	Attitude Accuracy	50.4.1	50.4.2
3.2.1.5	Latitude Range/Vehicle Motion During Alignment	-	50.4.2
3.2.1.6	Performance Certification	50.4.1	50.4.2
3.2.1.7	INS Functions	4.2.3.2	50.4.2
3.2.1.8	Selectable Modes	4.2.3.2	50.4.2
3.2.1.9	Data Output	4.2.3.2	-
3.2.2	Physical Characteristics	-	-
3.2.2.1	Size	4.2.3.1	-
3.2.2.2	Electrical Interface	4.2.3	-
3.2.2.3	Electrical Power	4.2.4.4	-
3.2.3	Reliability	-	-
3.2.4	Maintainability	4.2.7	
3.2.4.1	Design	4.2.7	
3.2.4.1.1	Calibration Interval	4.2.3	50.4.2
3.2.4.1.2	Maintainability Definitions	-	-
3.2.4.2	Repair	4.2.7	-
3.2.4.2.1	Organizational Level Maintainability Requirements	4.2.7	-
3.2.4.2.1.1	Equipment Handling	4.2.7	-
3.2.4.2.1.2	Adjustments	4.2.7	-
3.2.4.2.1.3	Boresighting	4.2.7	-
3.2.4.2.1.4	INBU Mount	4.2.7	-
3.2.4.2.2	Intermediate Level Maintainability Requirements	4.2.7	

TABLE A-2 CONTINUED

REQUIREMENTS	REFERENCE	LABORATORY	AIRCRAFT
3.2.4.2.2.1	Packaging	4.2.7	-
3.2.4.2.2.2	Adjustments	4.2.7	-
3.2.4.2.2.3	Reversibility Restrictions	4.2.7	-
3.2.4.2.2.4	Accessibility	4.2.7	-
3.2.4.3	Built-In-Test (BIT) Function	4.2.7	-
3.2.4.3.1	Failure Detection Function	4.2.7	-
3.2.4.3.1.1	Failure Detection Performance	4.2.7	-
3.2.4.3.2	Failure Location Function	4.2.7	-
3.2.4.3.2.1	Organizational Level	4.2.7	-
3.2.4.3.2.2	Intermediate Level	4.2.7	-
3.2.4.3.2.3	Failure Location Performance	4.2.7	-
3.2.5	Environmental Conditions	4.2.4.2	-
3.2.5.1	Temperature	4.2.4.2.1	50.4.2
3.2.5.2	Altitude	4.2.4.2.1	50.4.2
3.2.5.3	Vibration	4.2.4.2.3	50.4.2
3.2.5.3.1	Gunfire Vibration	4.2.4.2.15	-
3.2.5.4	Rain	4.2.4.2.5	-
3.2.5.5	Solar Radiation	4.2.4.2.9	-
3.2.5.6	Acoustic Noise	4.2.4.2.13	-
3.2.5.7	Flight Environment	4.2.3.2	50.4.2
3.2.5.8	Fluids	4.2.4	-
3.2.6	Transportability	4.2.1 & 4.2.7	-
3.3	Design and Construction	4.2.1	-
3.3.1	Useful Life	4.2.1 & 4.2.7	-
3.3.2	Operational Service Life	4.2.1 & 4.2.7	-
3.3.2.1	Storage	4.2.1 & 4.2.7	-
3.3.3	Design Loads	-	-
3.3.3.1	Normal Operating Load Factors	50.4.1.16	-
3.3.3.2	Limit Load Factors	4.2.4.2.11	-
3.3.3.3	Ultimate Load Factors	4.2.4.2.14	-
3.3.4	Thermal Design	4.2.4.2.4	-
3.3.4.1	Cooling Air Conditions	4.2.4.2.4	-
3.3.4.2	Cooling Air Flow	4.2.4.2.4	-
3.3.4.3	Resistance to Over-Cooling	4.2.4.2.4	-
3.3.4.4	Pressurization	4.2.4.2.4	-
3.3.4.5	Cooling Air Connectors	4.2.3.1	-
3.3.5	Electromagnetic Interference (EMI)	4.2.4.3	-
3.3.5.1	Bonding	4.2.4.3	-
3.3.5.2	General	4.2.4.3	
3.3.5.3	EMI Requirements	4.2.4.3	
3.3.5.4	Associated Criteria for EMC Control	4.2.4.3	
3.3.6	Nameplates and Product Marking	4.2.1	-
3.3.7	Workmanship	4.2.1	-

TABLE A-2 CONTINUED

REQUIREMENTS	REFERENCE	LABORATORY	AIRCRAFT
3.3.8	Safety	4.2.2	-
3.3.8.1	Safety Markings	4.2.1	-
3.3.9	Human Engineering	4.2.1	-
3.3.10	Elapsed Time Meter	4.2.1	-
3.3.11	Connectors	4.2.3.1	-
3.3.12	Parts, Materials and Processes	4.2.1	-
3.3.12.1	Microcircuits	4.2.1	-
3.3.12.2	Semiconductors	4.2.1	-
3.3.12.3	Passive Devices	4.2.1	-
3.3.12.4	Non-Standard Parts	4.2.1	-
3.3.13	Finishes and Colors	4.2.1	-
3.3.14	Handles and Grasp Areas	4.2.1	-
3.3.15	Environmental Protection	4.2.1	-
3.3.15.1	Toxicity	4.2.1	-
3.3.15.2	High Voltage	4.2.1 & 4.2.4.4	-
3.3.16	Hazard Protection	4.2.1	-
3.3.17	Switching Transients	4.2.1 & 4.2.4.4	-
3.3.18	Overload Protection	4.2.4.4	-
3.3.19	Modular Design	4.2.3.1	
3.3.20	Personnel and Training	4.2.1	
3.3.21	Computer Software	4.2.4.3	
3.3.21.2	Maintenance Program	4.2.7	
3.4	Logistics	4.2.7	
3.4.1	Maintenance	4.2.7	

4.2.4 Qualification Tests. In accordance with the basic specification.

4.2.4.1 Prequalification Acceptance Test. In accordance with the basic specification.

4.2.4.2 Environmental Tests. In accordance with the basic specification.

4.2.4.2.1 Temperature and Altitude.

(1) Force-Cooled Equipment. Per 4.2.4.2.1 of basic specification.

(2) Free-Convection Cooled Equipment. Per 4.2.4.2.1 of basic specification.

4.2.4.2.2 Humidity Test. In addition to the test requirements established in the basic specification, forced cooled equipment which is non-compliant with MIL-STD-454D, Requirement 52, paragraph 5.2, shall be subjected to a 24-hour humidity-in-the-cooling air test. The equipment shall be installed in a test chamber and chamber conditions of room pressure, 85°F and 96 percent relative humidity shall be established. Cooling air having a water content of 100 percent relative humidity plus 55 grains free water per pound of air shall be supplied continuously to the equipment at a flow rate of not lower than that specified in paragraph 3.3.4 of this addendum for a supply temperature of 80°F. The first 4 hours of the test shall be performed with cooling air supplied at 80°F and the next 4 hours with cooling air supplied at 35°F. This cooling air supply temperature cycle shall be repeated 3 times. The transition time to change the supply air temperature shall not exceed 5 minutes. The equipment shall be operated for the first 2 hours of exposure and shall be inoperative (de-energized for the succeeding 4 hours). This sequence shall be repeated 4 times. Stabilized data shall be recorded during each operating period. Neither adjustments other than normal control operations nor removal of moisture accumulations will be permitted during the 24-hour exposure. Immediately upon completion of the exposure the equipment shall be visually inspected, with disassembly as necessary. Evidence of internal moisture accumulations, arcing or other deleterious moisture effects as well as improper functional performance during or as a result of exposure shall constitute reason to consider the equipment as having failed to meet specified requirements.

4.2.4.2.3 Random Vibration. In accordance with the basic specification.

4.2.4.2.4 Cooling Air. In accordance with the basic specification.

4.2.4.2.5 Rain. In accordance with the basic specification.

4.2.4.2.6 Sand and Dust. In accordance with the basic specification.

4.2.4.2.7 Fungus. In accordance with the basic specification.

4.2.4.2.8 Salt Fog. In accordance with the basic specification.

4.2.4.2.9 Solar Radiation. In accordance with the basic specification.

4.2.4.2.10 Explosive Atmosphere. In accordance with the basic specification.

4.2.4.2.11 Linear Acceleration Limit Load. In accordance with the basic specification.

4.2.4.2.12 Sinusoidal Vibration. In accordance with the basic specification.

4.2.4.2.13 Acoustic Noise. In accordance with the basis specification.

4.2.4.2.14 Shock. In accordance with the basic specification.

4.2.4.2.15 Gunfire Vibration. In accordance with the basic specification.

4.2.4.2.16 Toxicity. In accordance with the basic specification.

4.2.4.3 Electromagnetic Interference (EMI) Test. All phases of operation of the INS shall be tested as specified in MIL-STD-462 for compliance with the requirements of 3.3.2 of this addendum. A test plan for these tests shall be prepared by the manufacturer and approved by the procuring activity. A test report covering these tests shall be prepared by the manufacturer and approved by the procuring activity.

4.2.4.4 Electrical Power Test. Electrical Power tests shall consist of power variation and usage tests and an analysis as specified below.

a. Power Variation and Usage Tests. Tests shall be conducted to demonstrate that the INS performs satisfactorily under power input conditions as specified in paragraphs 5.1.3, 5.1.3.1, 5.1.3.2, 5.1.3.4, 5.1.4, 5.1.4.1, 5.1.4.2, 5.1.5, 5.1.6, 5.1.6.1, 5.2.1, 5.2.2, 5.2.2.1, 5.2.3, 5.3.2.1, 5.2.3.2, 6.9.3, 6.9.4, 6.9.5 and 6.10 of MIL-STD-704A. The INU input power shall be measured and shall be in accordance with paragraph 3.2.2.3 of Addemdum A herein.

b. Analysis. The following paragraphs of MIL-STD-704A shall be verified by test or analysis, whichever is deemed most feasible: 5.1.3.3, 5.1.3.5, 5.1.3.6.1, 5.1.3.6.2, 5.1.5.1, 5.1.5.2, 5.1.5.3, 5.1.6.2, 6.8, 6.8.1, and 6.8.2.

4.2.4.4.1 DC Power. In accordance with the basic specification.

4.2.4.4.2 Power Consumption. The AC and DC inputs shall be monitored and recorded. The aircraft power (start-up and running) shall not exceed the limits shown in paragraph 3.2.2.3 of this addendum.

4.2.4.4.3 Power Failure Indication. In accordance with the basic specification.

4.2.4.5 Post Qualification Functional Test. In accordance with the basic specification.

4.2.5 Combined Environmental Test (CET). In accordance with the basic specification.

4.2.5.1 Test Samples. In accordance with the basic specification.

4.2.5.2 Test Procedure. In accordance with the basic specification.

4.2.6 Production Verification Test (PVT). In accordance with the basic specification.

4.2.6.1 Procedure. In accordance with the basic specification.

4.2.6.1.1 Random Vibration. In accordance with the basic specification.

4.2.6.1.2 Temperature Cycles. In accordance with the basic specification.

4.2.6.1.2.1 Temperature Cycle Steps. In accordance with the basic specification.

4.2.6.2 Failure and Retest Criteria. In accordance with the basic specification.

4.2.6.2.1 Failures Necessitating INS Retest During PVT. In accordance with the basic specification.

4.2.6.2.2 Retest Criteria. In accordance with the basic specification.

4.2.6.2.3 PVT Trial Cycles. In accordance with the basic specification.

4.2.6.3 Failure Reporting and Analysis. In accordance with the basic specification.

4.2.6.3.1 Test Log Book. In accordance with the basic specification.

4.2.7 Maintainability/BIT Demonstration. In accordance with the basic specification.

4.2.7.1 General. In accordance with the basic specification.

4.2.7.2 Equipment Repair Time. In accordance with the basic specification.

4.2.7.3 Failure Detection. In accordance with the basic specification.

4.2.7.4 Failure Location. In accordance with the basic specification.

4.3 Reliability Tests.

4.3.1 Preproduction Phase. The specified MTBF (θ_0) of paragraph 3.2.3 of this addendum shall be demonstrated by reliability qualification testing per MIL-STD-781B, Test Plan III, Test Level F. The detailed test requirements shall be in accordance with MIL-STD-781B except as modified by 4.2.6 of the basic specification. The test shall be performed on at least three (3) deliverable equipments.

4.3.2 Production Phase. The specified MTBF (θ_0) of paragraph 3.2.3 of this addendum shall be demonstrated by reliability qualification testing per MIL-STD-781B, Test Plan V, Test Level F. The detailed test requirement shall be in accordance with MIL-STD-781B except as modified by 4.2.6 of the basic specification. The test shall be performed on at least five (5) deliverable equipments from the first twenty-five (25) deliverable equipments.

4.4 Safety-of-Flight Test. Safety-of-flight tests shall be conducted prior to delivery of the first airplane system to insure that the equipment is safe to use in an airplane. These tests shall include, in addition to those required in the basic specification, the following:

a. Temperature-Altitude. In accordance with paragraph 4.2.4.2.1 of the addendum.

b. b. Vibration. In accordance with paragraphs 4.2.4.2.3 and 4.2.4.2.12 of the addendum.

c. Shock. In accordance with paragraph 4.2.4.2.14 of the addendum.

d. Explosion Atmosphere. In accordance with paragraph 4.2.4.2.10 of the addendum.

e. Power Characteristics Test. In accordance with paragraph 4.2.4.4 of Addendum A herein.

(1) DC Voltage. The INS shall not be damaged when supplied with DC voltage between Limit 1 and Limit 4, Figure 6, MIL-STD-704.

(2) Voltage Loss. The INS shall not sustain damage due to a loss of one (1) phase or one (1) voltage and shall comply with the requirements of abnormal electric system operation as specified in MIL-STD-704.

f. Safety of Flight EMC Test. The INS shall be tested as specified in MIL-STD-462 for compliance with the requirements of paragraph 3.3.5.3 and RE02 of MIL-STD-461. Certification of satisfactory completion of these tests shall be submitted to the procuring activity prior to the delivery of the first airplane system.

5.0 Preparation for Delivery.

5.1 General. In accordance with the basic specification.

6.0 Notes.